

CERES CLOUD WORKING GROUP STATUS

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CERES Telecon, September 19, 2001

- CALIBRATION

- Paper submitted to *J. Atmos. Oceanic Technol.* showing stability of VIRS using ATSR-2, CERES, and GOES data. Also includes comparison of provisional MODIS and VIRS. Day-night low temperature difference examined.
- Paper in preparation showing calibration of VIRS 1.6 μm using ATSR-2, MODIS, MAS, and model calculations

- ALGORITHM STUDIES

- CLOUD RETRIEVAL PARAMETERIZATION
- CLOUD MASK CHANGES
 - VZA DEPENDENCE
 - DAYTIME POLAR

CHANGES TO CLOUD MASK (Ed 2)

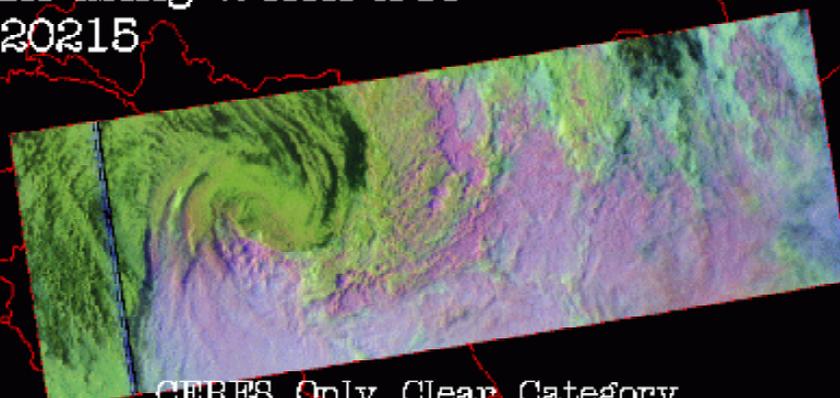
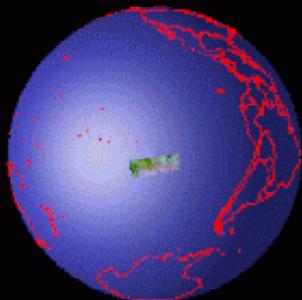
- DN1. Used VZA dependent thresholds to reduce VZA-dependence of cloud amount**
 - D2. Improved low clouds detection over sun glint and non-glint ocean from C1, C3.**
 - D3. Used ratio of 1.6 to 0.6 test to improve cloud detection over land from C1 and C3.**
 - D4. Added elevation dependent snow tests and Ci-test thresholds.**
 - D5. Improved the Welch tree: over non-glint water, if CERES cloud mask says weak clear and Welch mask says cloudy, overwrite CERES weak clear with strong clouds.**
-
- N1. Improved E2 test by adding T4-T5 test to reduce unreal weak clouds.**
 - N2. Added thin Ci detection in E3 test for land and ocean.**
 - N3. Increased the ocean clear sky 3.7-11 micron standard deviation from 1.5 to 2.0.**

Improved the Welch tree: over non-glint water
 if CERES cloud mask says weak clear & Welch mask says cloudy,
 overwrite CERES weak clear with strong clouds.

Use Welch Mask to Refine CERES Cloud Mask

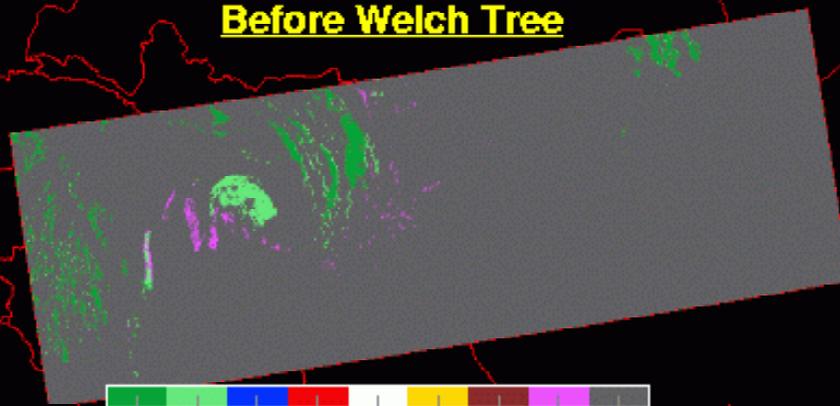
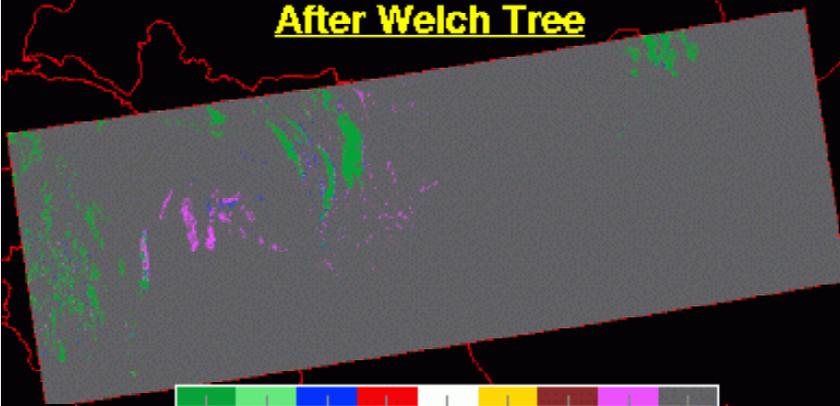
CERES Cloud Mask	VISST	Welch Mask	Final Cloud Mask
weak clouds weak clouds	no retrieval no retrieval	clear aerosol	clear weak clear aerosol
weak clear weak clear weak clear		clear aerosol smoke, haze	clear strong clear aerosol clear smoke
weak clear over non-glint ocean, but at least one B tests say cloudy		cloudy (water, ice, or mixed)	strong cloud

VIRS, Improved Mask using Welch tree 1998020215



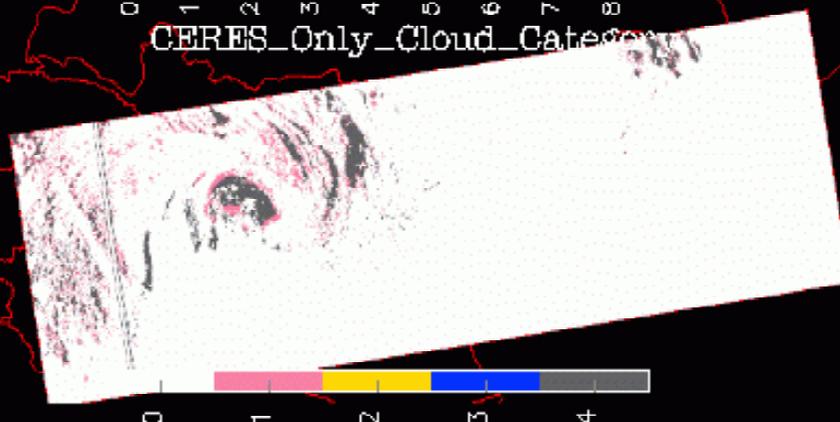
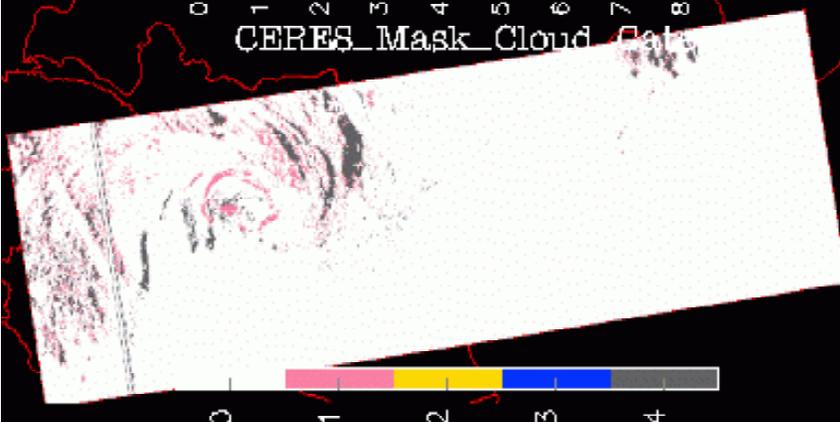
CERES_Mask_Clear_Category
After Welch Tree

CERES_Only_Clear_Category
Before Welch Tree

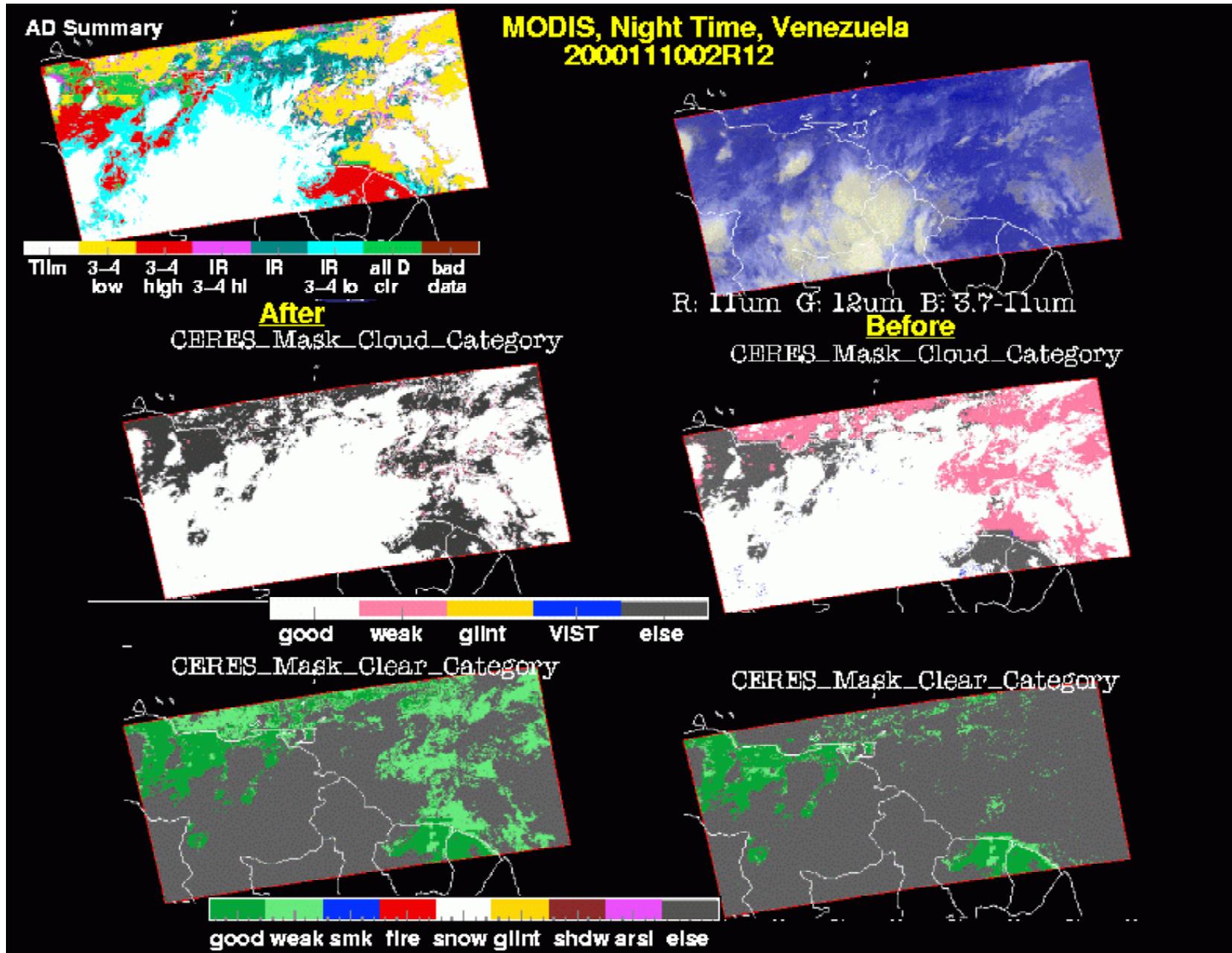


CERES_Mask_Cloud_Category

CERES_Only_Cloud_Category



Improved E2 test by adding T4-T5 test to reduce unreal weak clouds.



POLAR MASK

P1. Improved the clear sky snow models for 0.6 , 1.6 and 3.7 micron using MODIS observations.

P2. Improved the clear land detection (after snow melts).

P3. Reduced the uncertain pixels at high sun angles and high view angles.

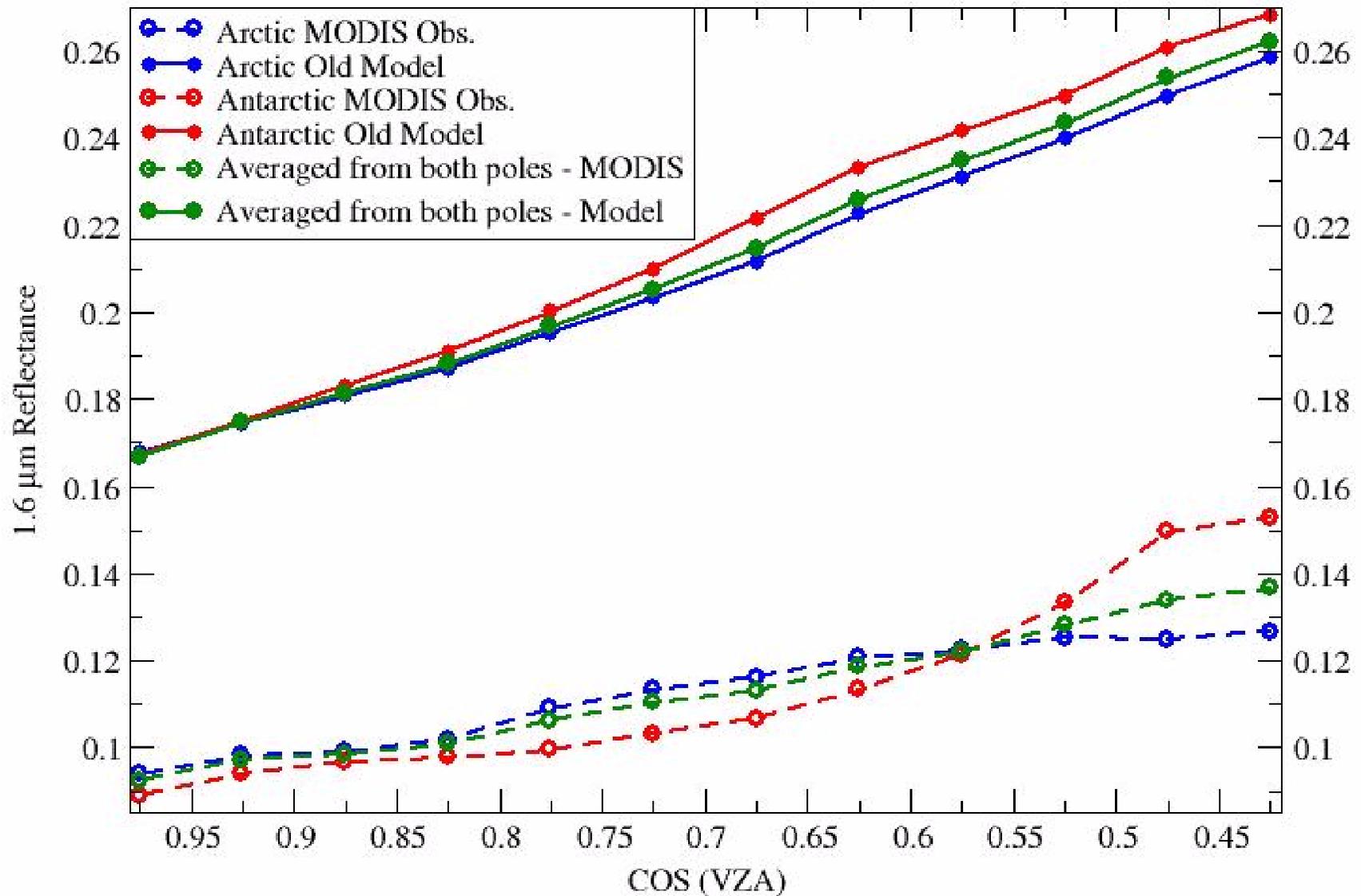
P4. Improved the ice clouds detection.

P5. Adjusted the thresholds for 3.7-11 micron BTD test and 3.7 reflectance test for the new MODIS calibrations.

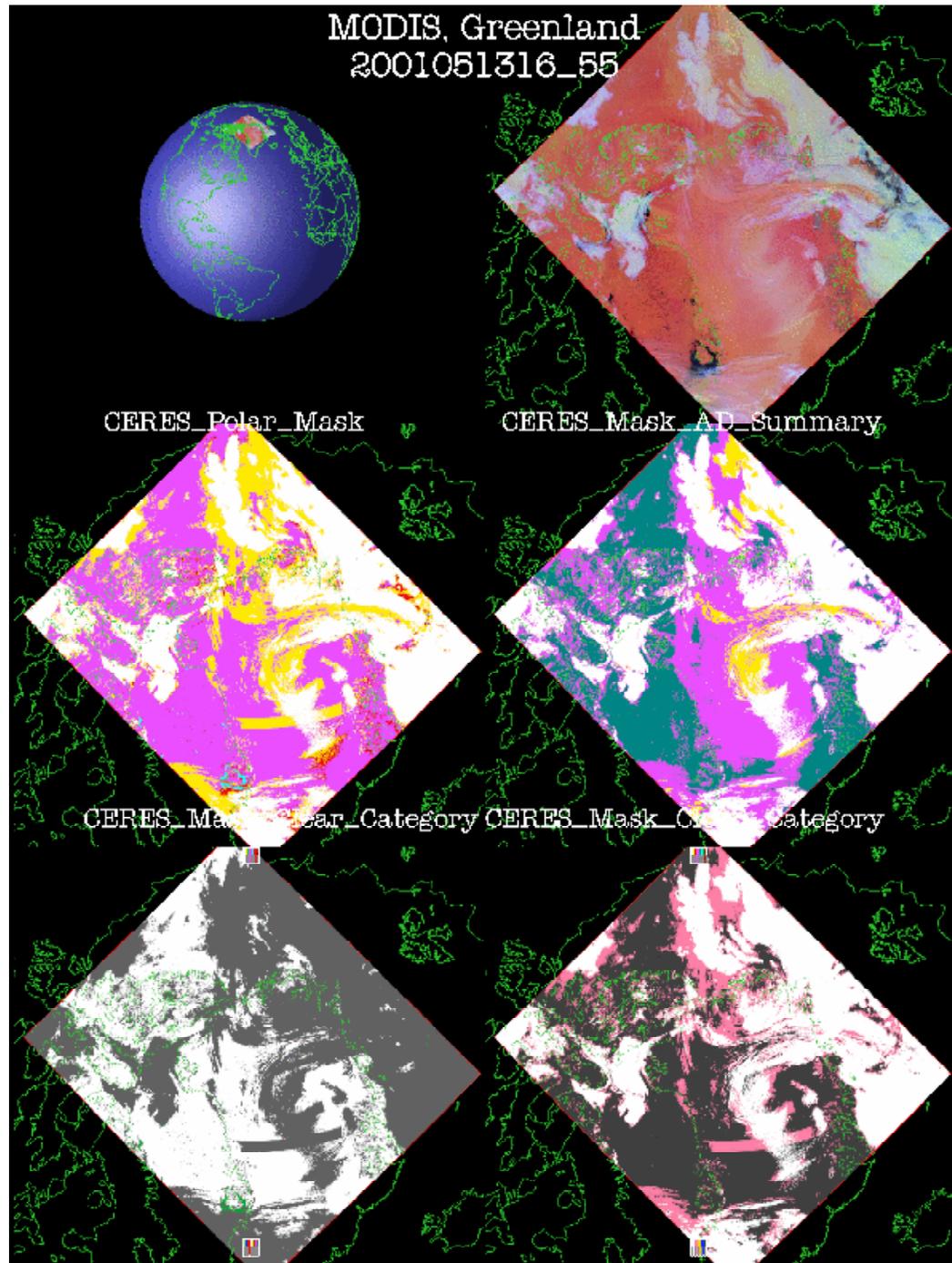
Improved clear sky-snow models for 0.6 , 1.6 and 3.7 μm using MODIS data.

Comparison of Snow and Ice Reflectance between MODIS and Model

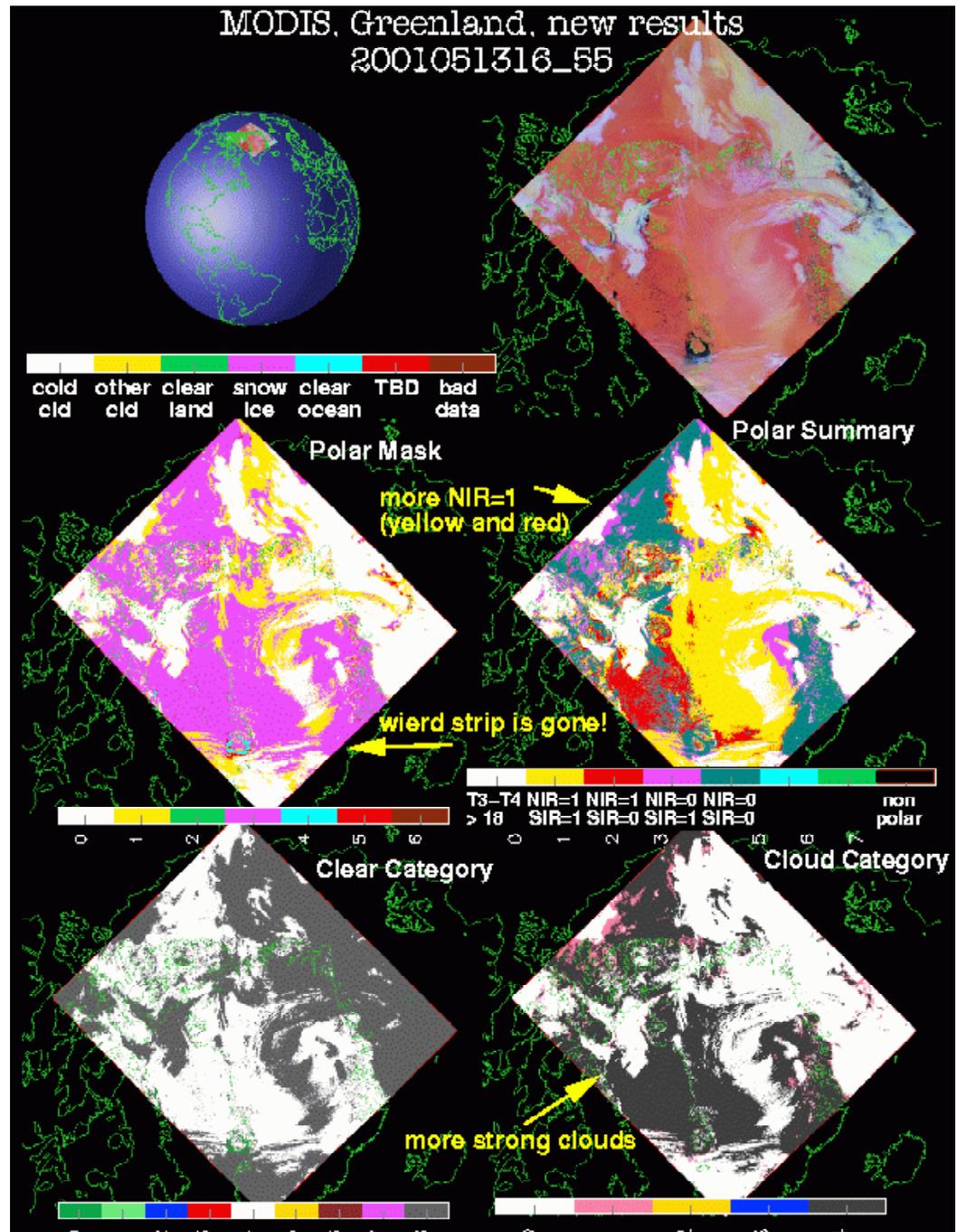
14 granules from Arctic and 14 granules from Antarctic



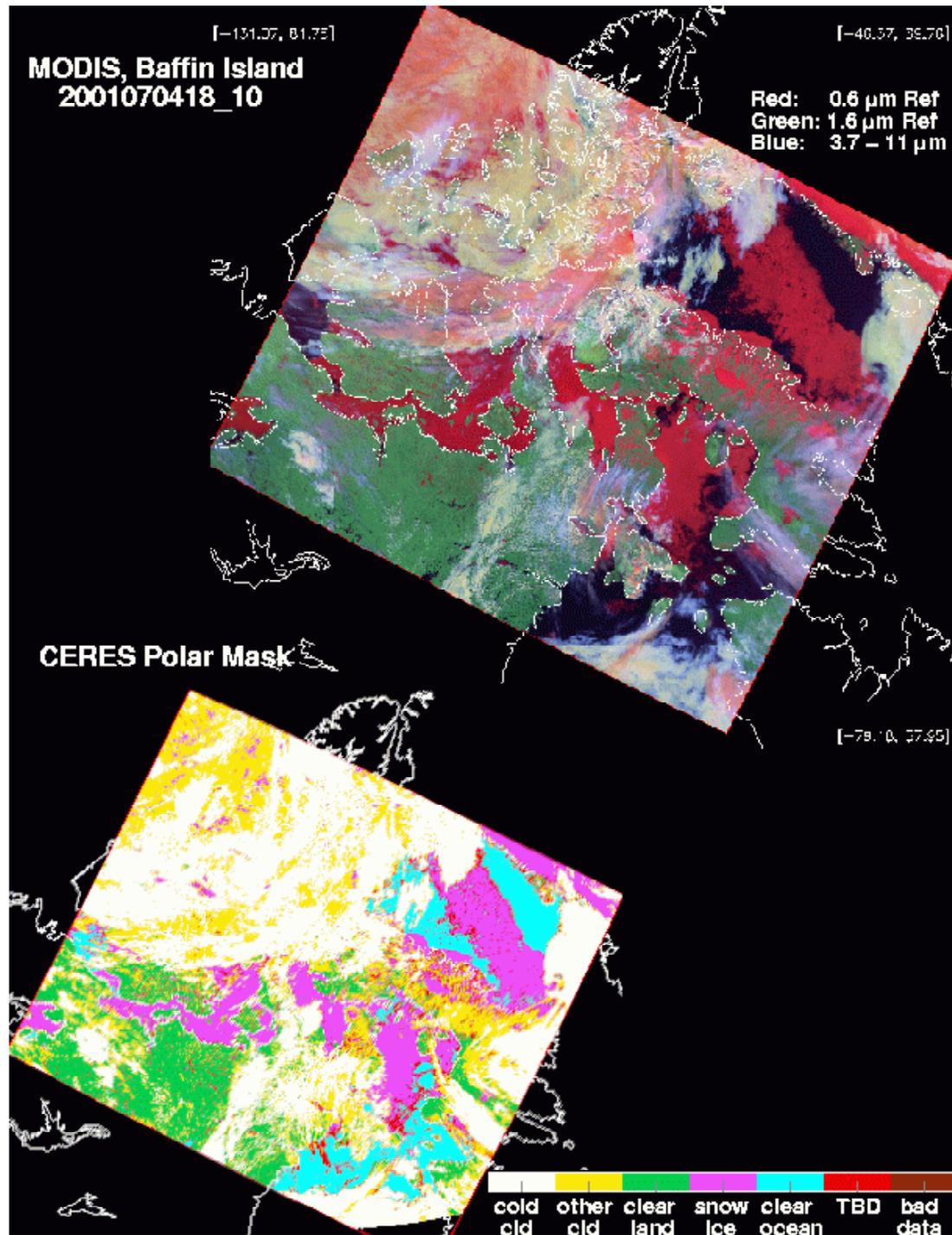
POLAR MASK USING OLD MODELS



POLAR MASK USING NEW MODELS



EXAMPLE OF IMPROVED DAYTIME POLAR MASK



OTHER CLOUD CODE CHANGES

- **Implemented hi-res cloud reflectance models (5° VZ & SZ, 21 RAZ nodes)**
- **1.6- μm cloud retrieval test & validated, not implemented**

VINT: Visible Infrared Near-infrared Technique

- **Corrected interpolation errors in marine strat cloud height estimation**
- **Used updated clear-sky albedo maps from Ed 1 in TRMM Ed 2**
- **Correct VIRS 1.6 μm radiance due to temperature variations of the detector.**
- **Implemented Stowe's 3rd generation AOT algorithm**

MODIS-RELATED CHANGES TO CLOUD CODE

- **MODIS correlated k calculations used for atmospheric absorption**
- **Visible-free daytime retrieval algorithm for polar regions tested and validated, but not turned on yet (clear background is a problem)**

SINT: Solar-infrared Infrared Near-infrared Technique

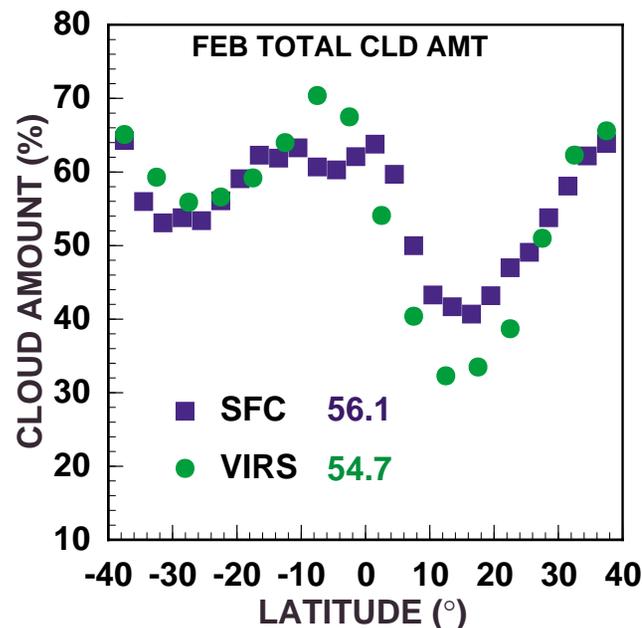
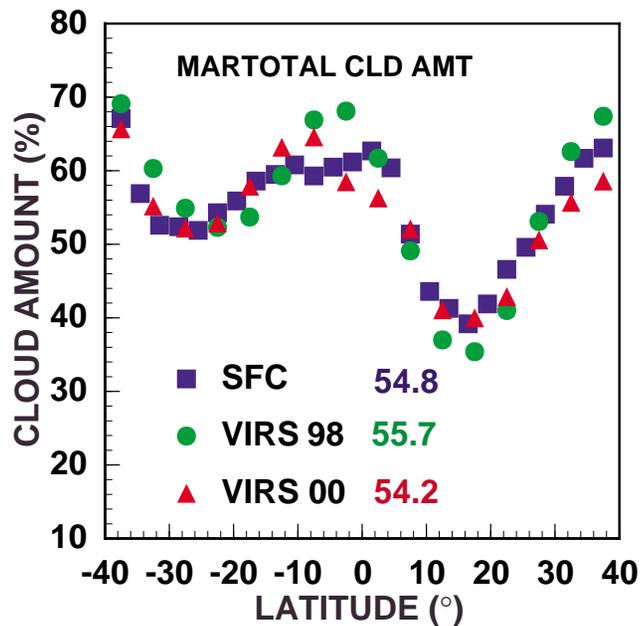
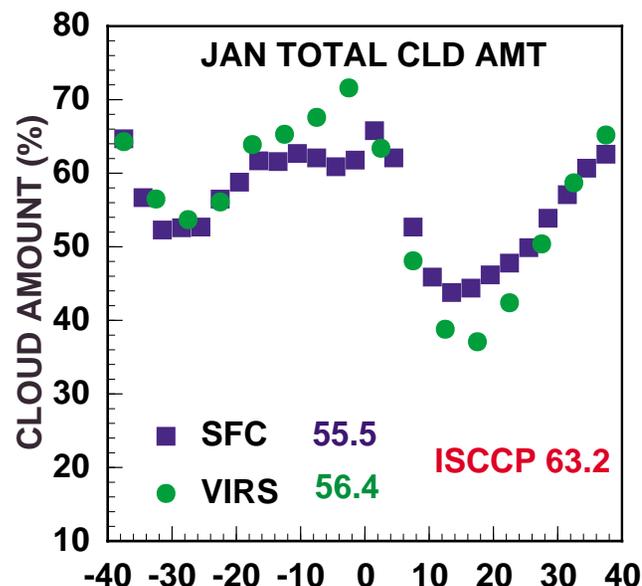
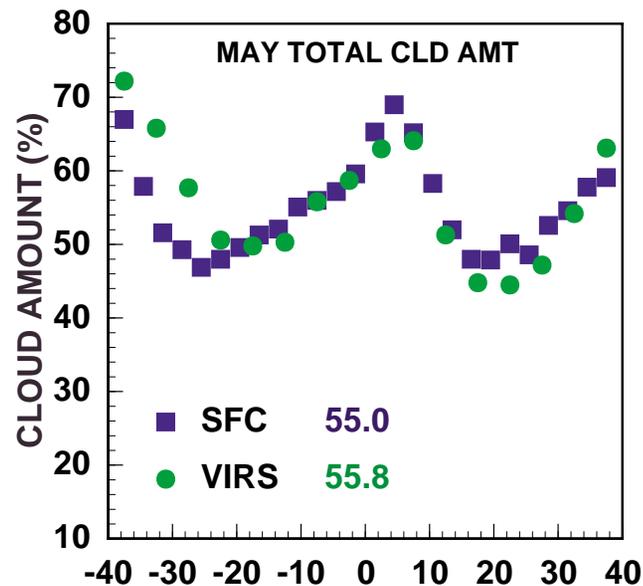
- **Improved 0.6 μ m, 1.6 μ m, 3.7 μ m clear-sky prediction over snow/ice.**
- **New MODIS reader to read subsetting MODIS radiance file (2x2) and match geolocation file (1x1). This reader can handle both versions (version 1 and version 3), where the difference is the channel selection.**
- **No 3.7 μ m calibration adjustment used for MODIS.**

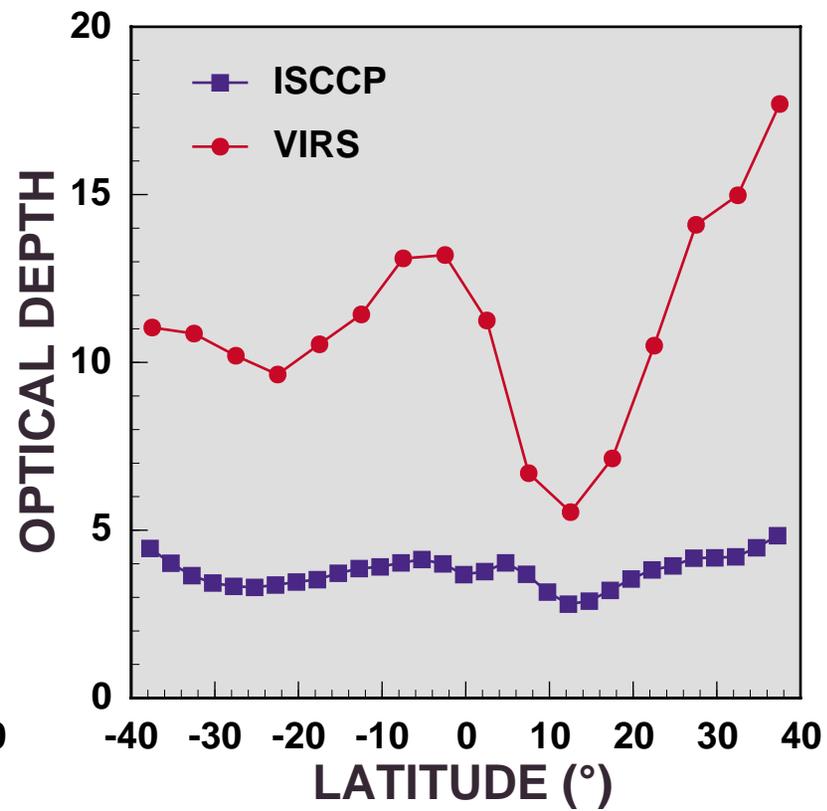
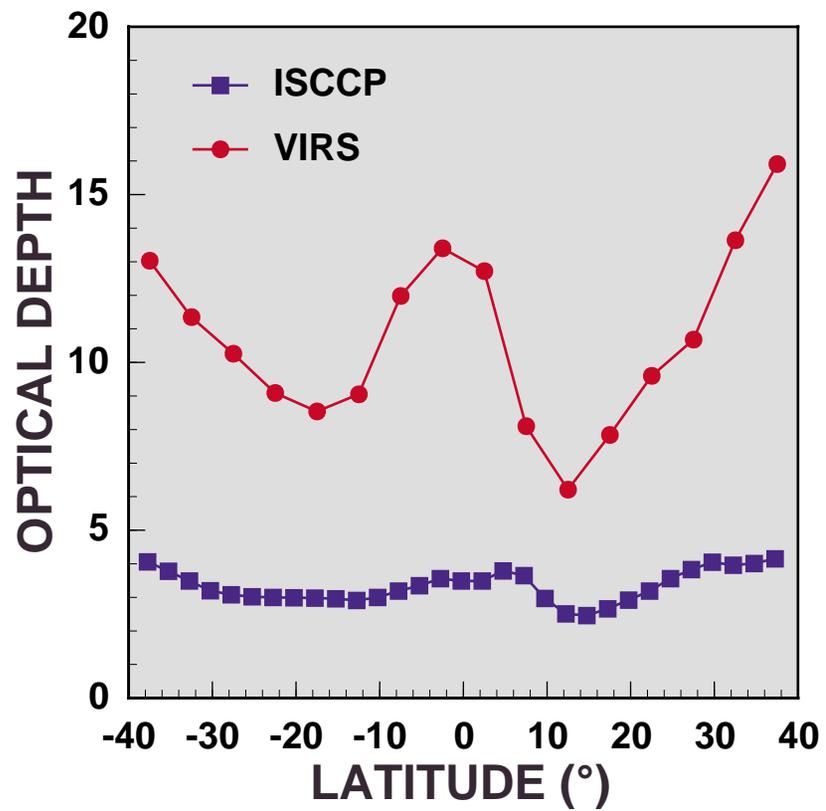
RESULTS

COMPARISONS WITH CLIMATOLOGY

COMPARISON OF TOTAL CLOUD AMOUNTS

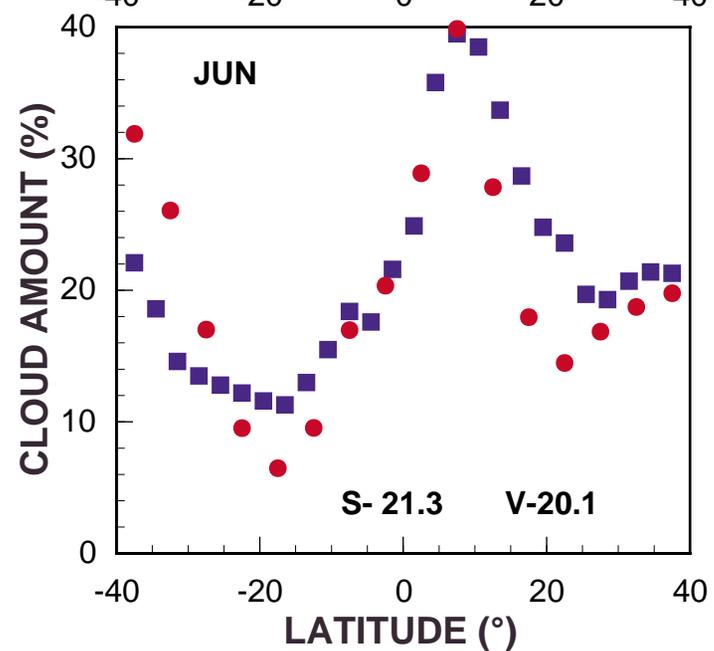
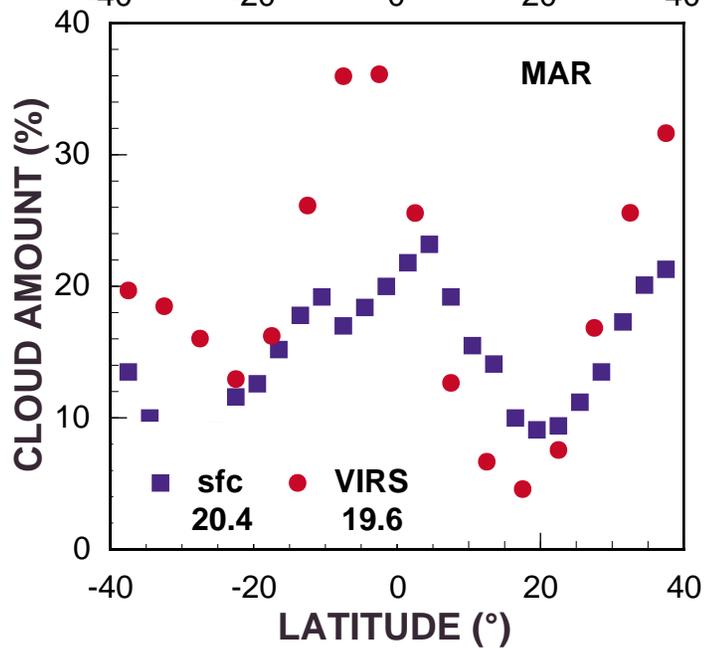
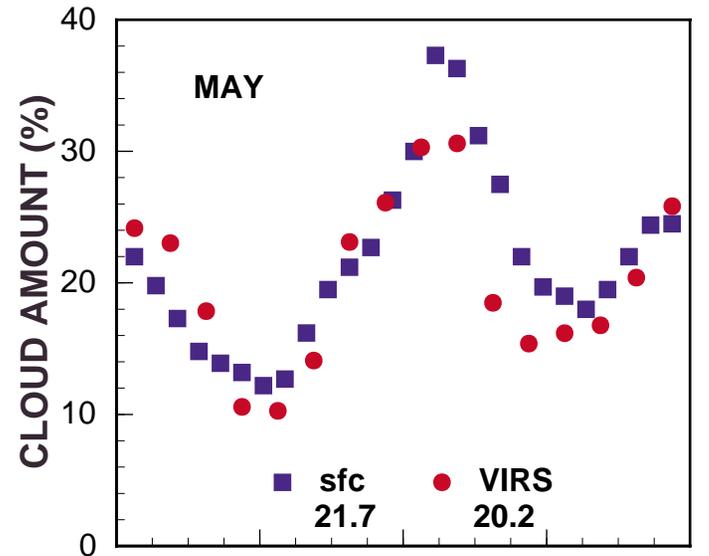
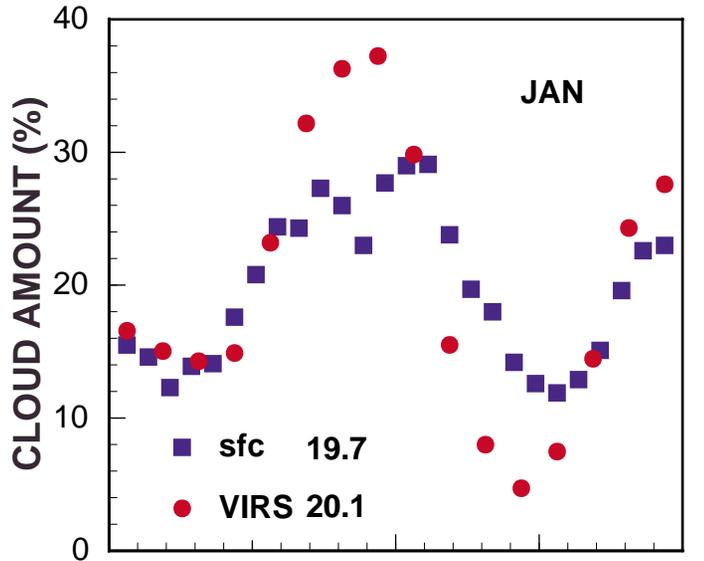
SURFACE (1971-1996) **VIRS (1998)** **ISCCP (1984 - 1991)**





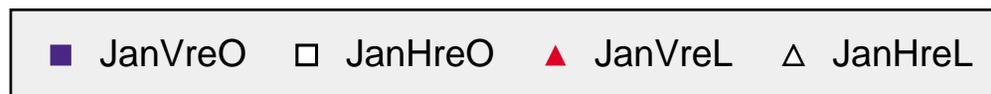
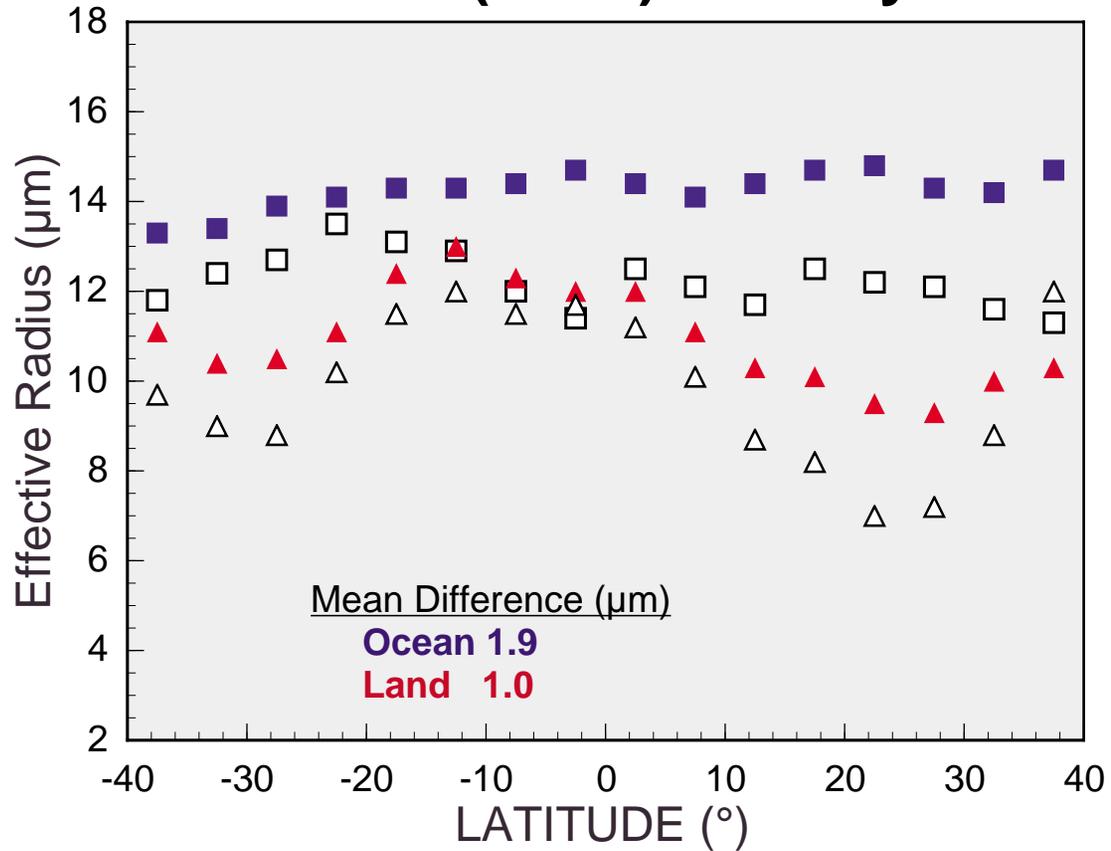
COMPARISON OF SFC-OBSERVED HIGH CLOUD AMOUNTS (1971-1996) AND VIRS-DERIVED COVERAGE BY ICE CLOUDS

VIRS sees 1% fewer ice clouds than SFC



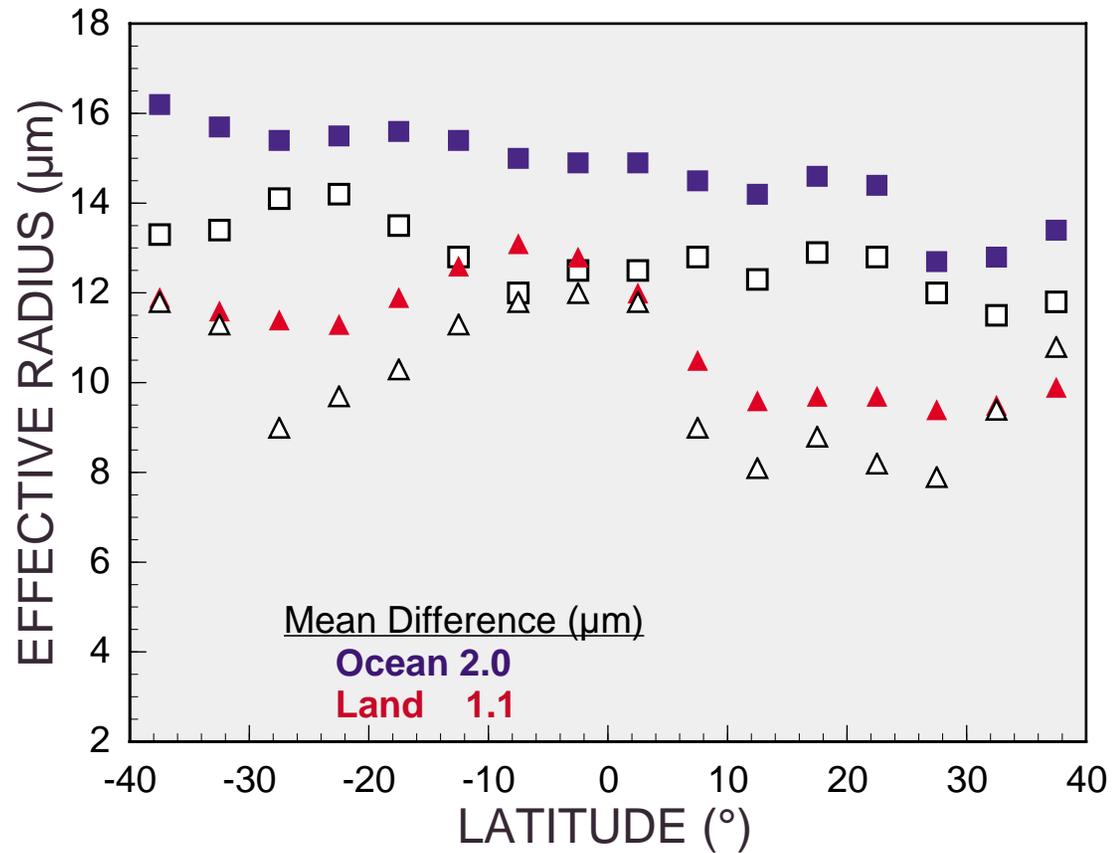
JANUARY EFFECTIVE RADIUS

AVHRR 1987 (Han) open symbols
CERES 1998 (VIRS) solid symbols



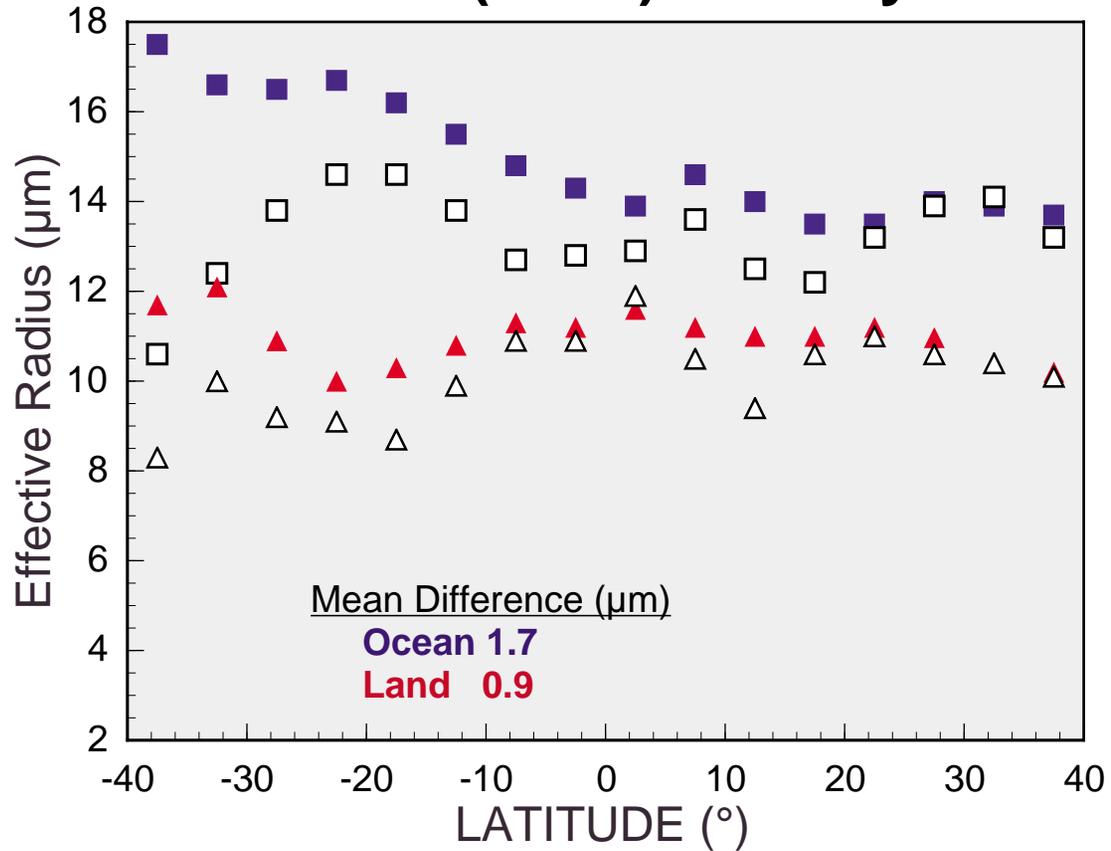
APRIL EFFECTIVE RADIUS

AVHRR 1987 (Han) open symbols
CERES 1998 (VIRS) solid symbols



JULY EFFECTIVE RADIUS

AVHRR 1987 (Han) open symbols
CERES 1998 (VIRS) solid symbols



COMPARISONS WITH PREVIOUS DATA

- VIRS-derived r_e is greater than HAN NOAA-9 r_e by
 - ~ 1.9 μm over ocean
 - ~ 1.0 μm over land
- SEASONAL TRENDS SIMILAR
ZONAL TREND DIFFERENCES VARIABLE
- DIFFERENCES MOST LIKELY DUE TO
 - Inclusion Of Overlapped Clouds, All taus
 - Inclusion Of Partially Filled Pixels
 - SZA Dependencies
 - Slight Errors In Emittance Parameterizations
 - Different atmospheric profiles/corrections

EFFECT OF MULTIPLE LAYERS ON RETRIEVED r_e 1 YEAR OF GOES-8 RETRIEVALS OVER ARM SITE

Clouds with a thin layer of cirrus above a low-level deck appear to have larger droplets than single-layer water clouds

A similar effect is realized for broken clouds

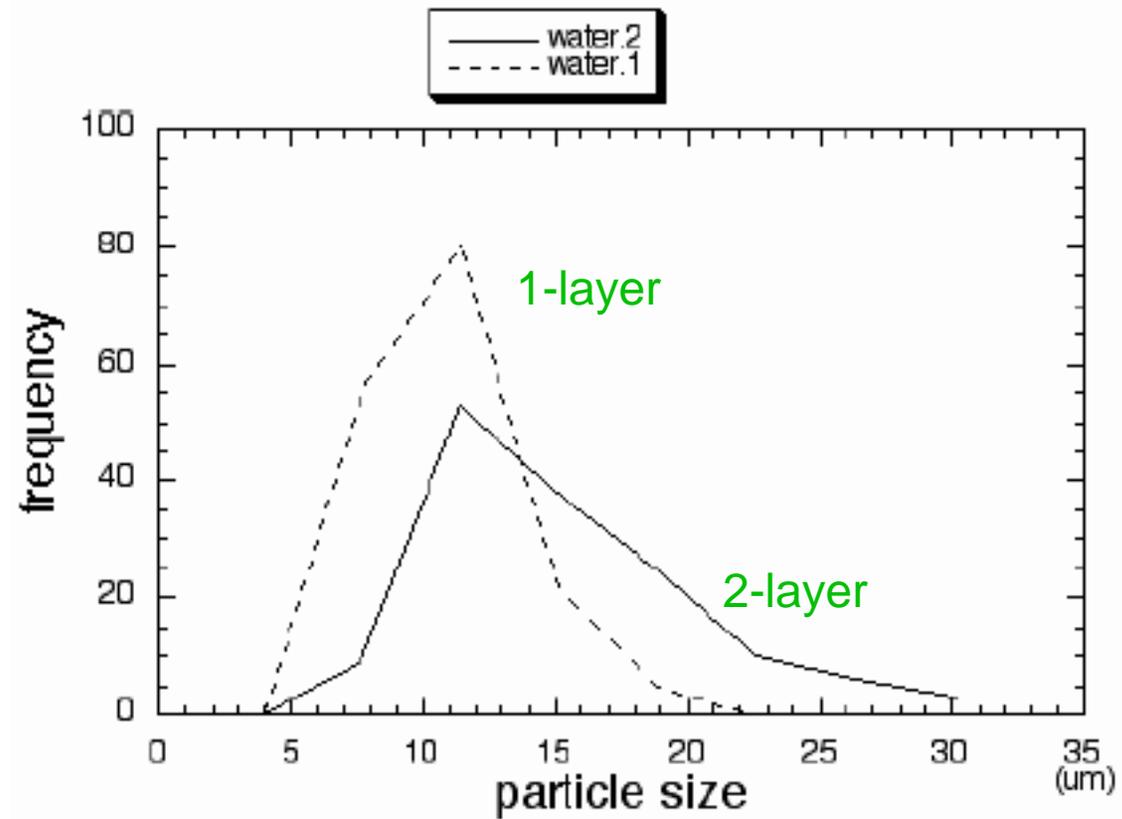


Figure 6. Histograms of cloud water droplet radius for single and multi-layered clouds.

EFFECT OF MULTIPLE LAYERS ON RETRIEVED D_e 1 YEAR OF GOES-8 RETRIEVALS OVER ARM SITE

Clouds with a thin layer of cirrus above a low-level deck appear to have smaller ice crystals than single-layer cirrus clouds

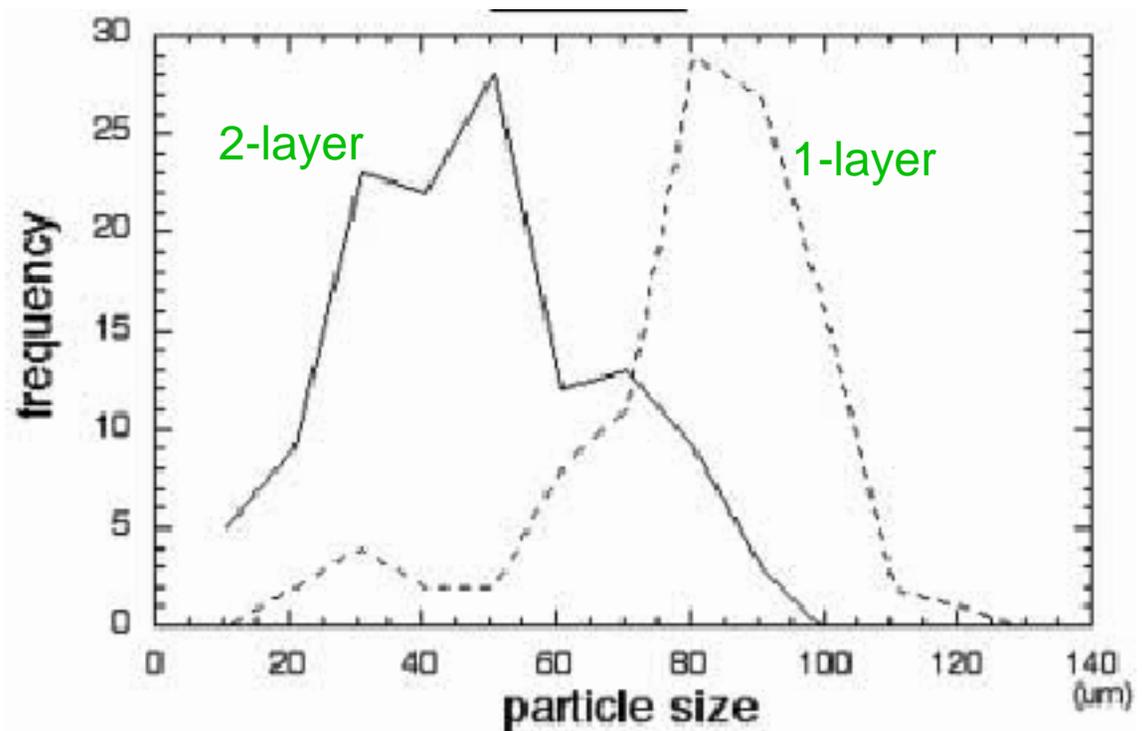


Figure 7. Same as Figure 6, except for cloud ice crystal diameter.

COMPARISONS WITH SURFACE DATA

A Year of Cloud Property Comparison Between CERES/VIRS and Surface Data at the ARM SGP

**X. Dong, P. Minnis, S. Sun-Mack,
G.G. Mace, E.E. Clothiaux, and J. Liljegren**

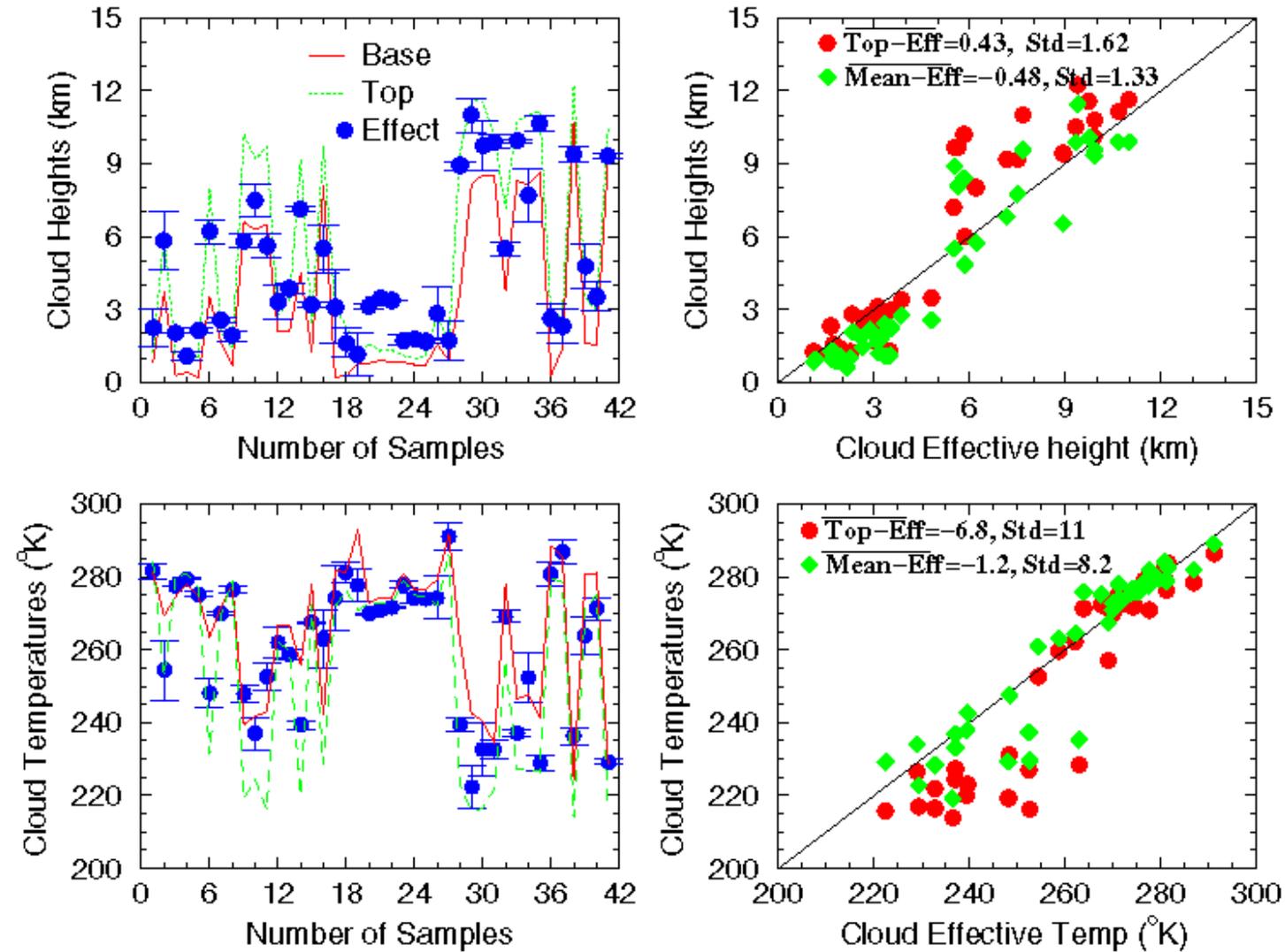
Contents:

- 1. To validate CERES/VIRS macrophysical and microphysical cloud properties using surface data (Updated)**
- 2. Preliminary validation of MODIS results using surface data at the ARM SGP and NSA Sites**

What's New for VIRS validation ?

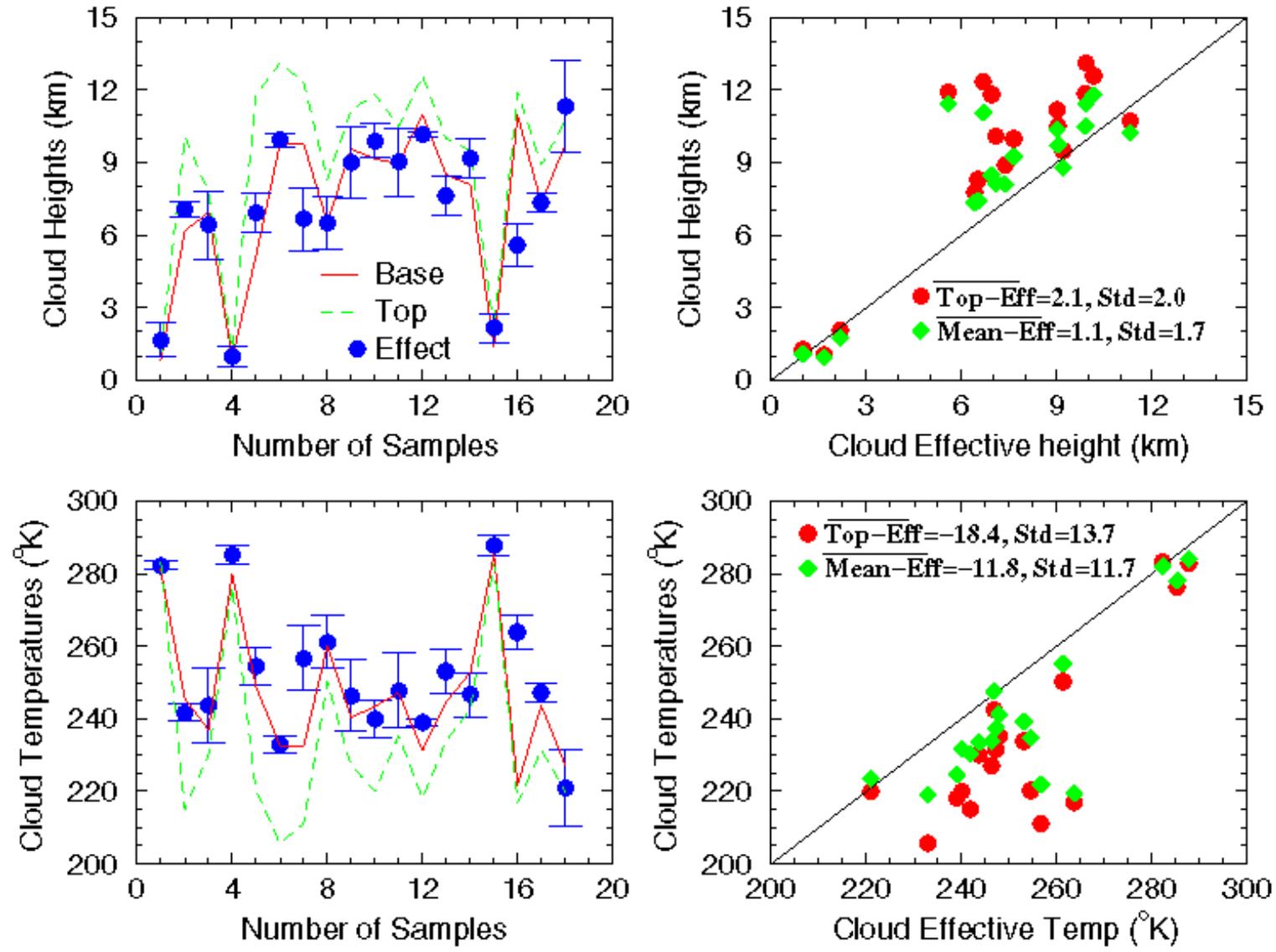
- **4 more months data (from Sept. to Dec. 1998)**
- **Total 59 cloud samples at Daytime, 80 samples at nighttime during 1998**
- **Updated CERES/VIRS retrievals**
- **Updated surface results**

Daytime VIRS and Surface Comparison at ARM SGP Site ($\tau > 5$)



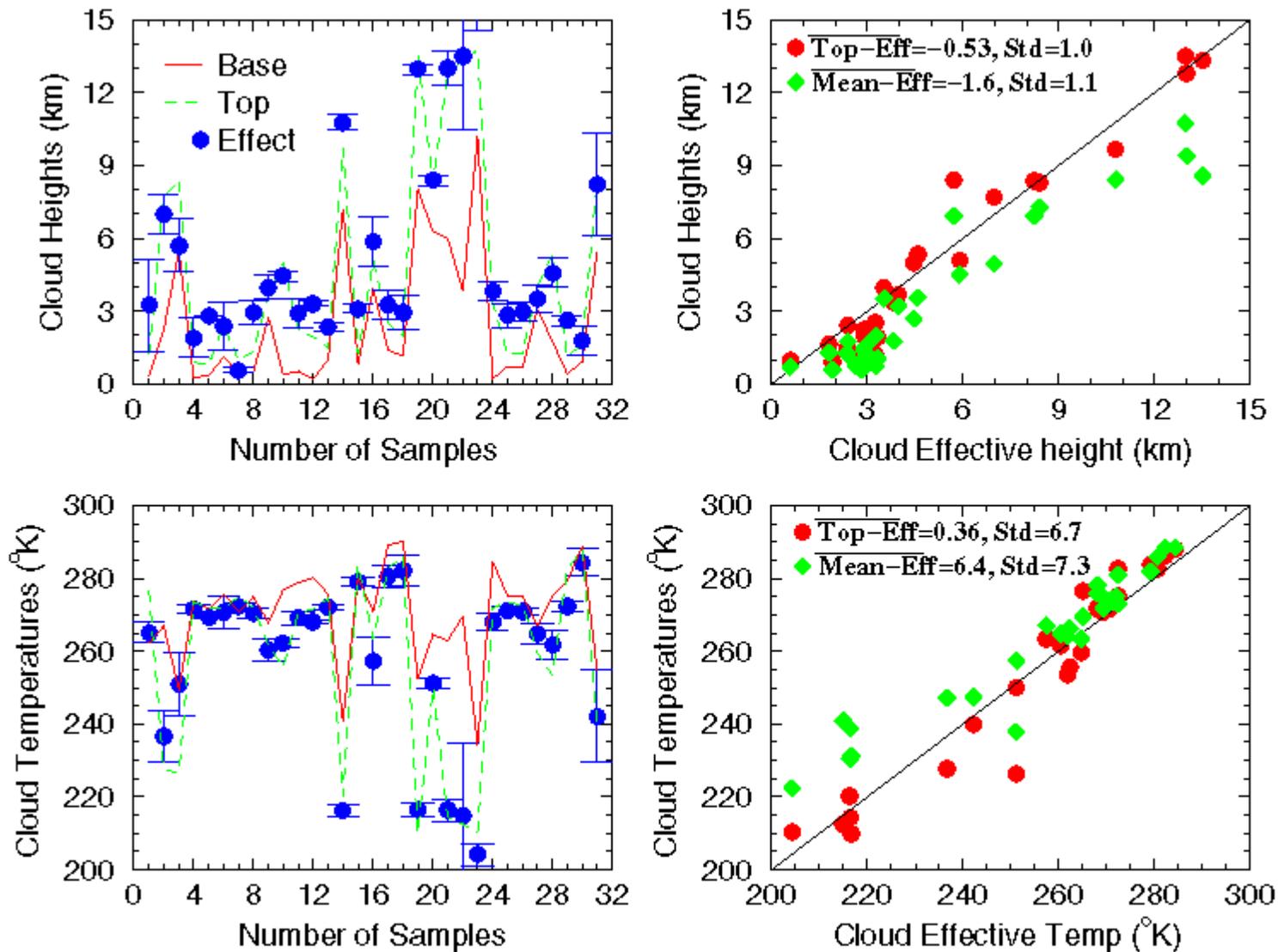
Daytime thick clouds: 5 stratus cloud tops outside of bounds, T(z) problem

Daytime VIRS and Surface Comparison at ARM SGP Site ($\tau < 5$)



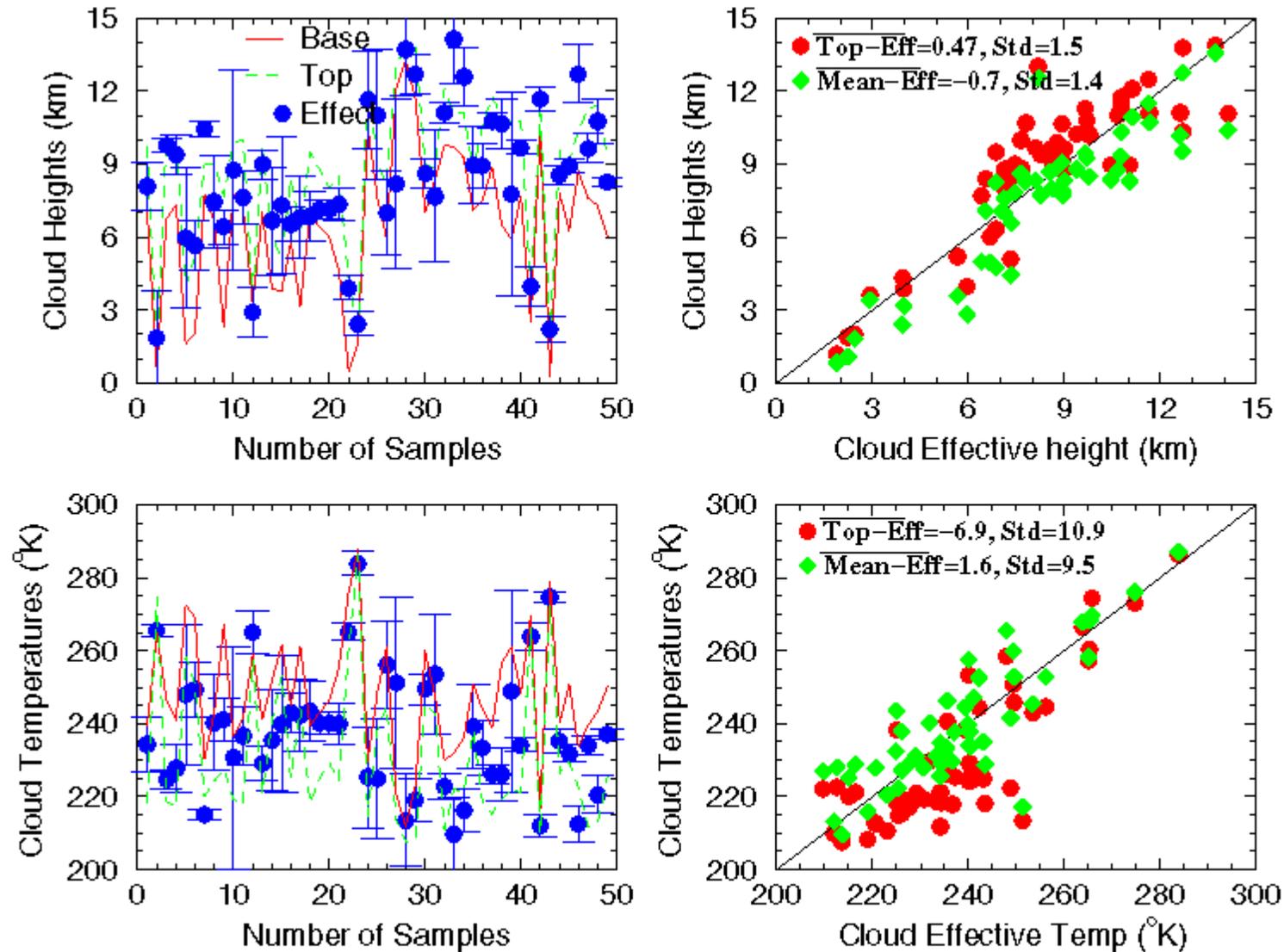
Thin cloud daytime: 3 below cloud base, 1 above cloud top

Nighttime VIRS and Surface Comparison at ARM SGP Site ($\tau > 5$)



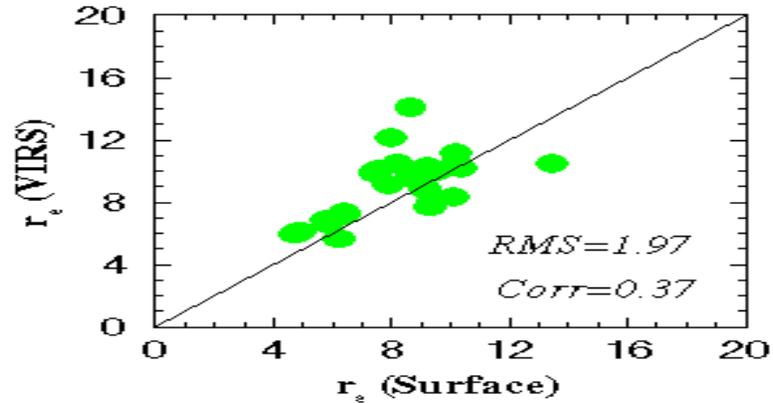
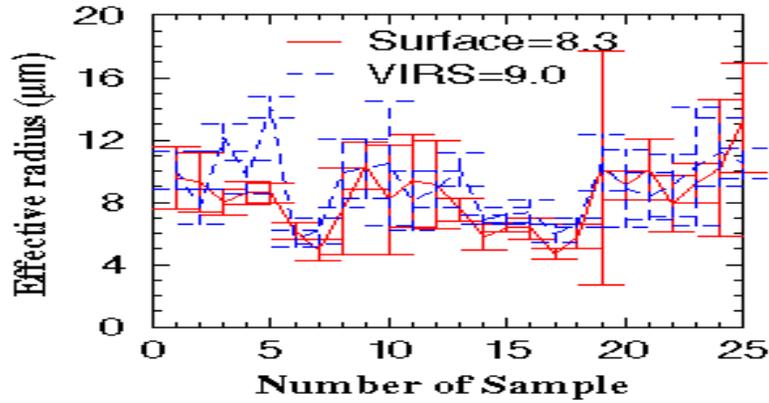
Nighttime thick: 2 cirrus too high, 3 stratus too high [T(z) again]

Nighttime VIRS and Surface Comparison at ARM SGP Site ($\tau < 5$)

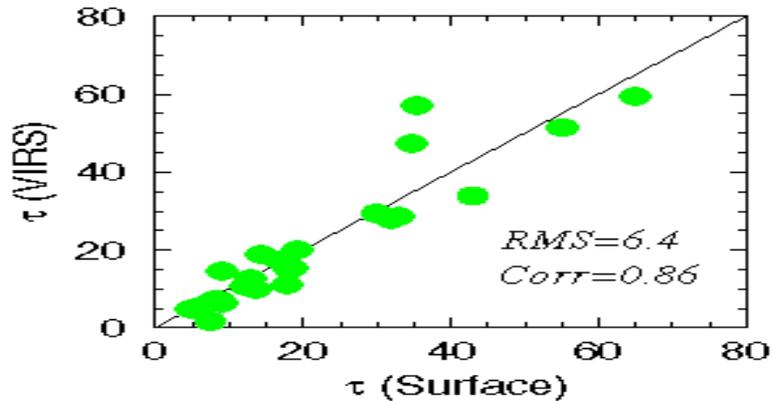
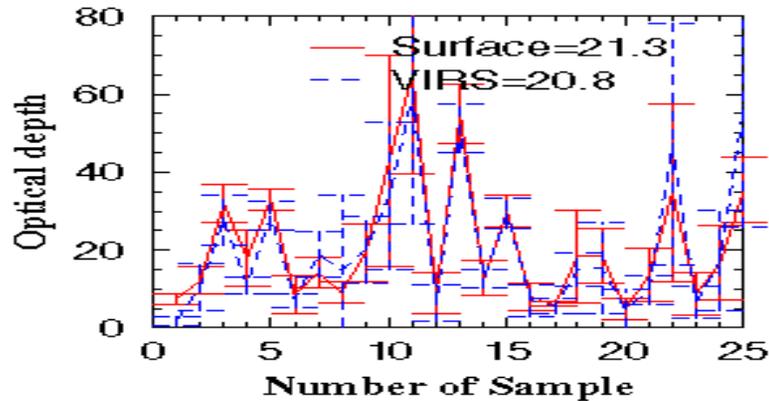


Nighttime thin: 4 Ci too high, 1 too low; best agreement

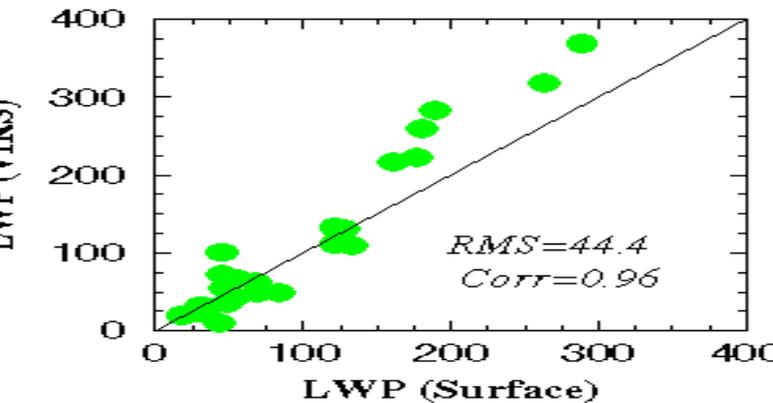
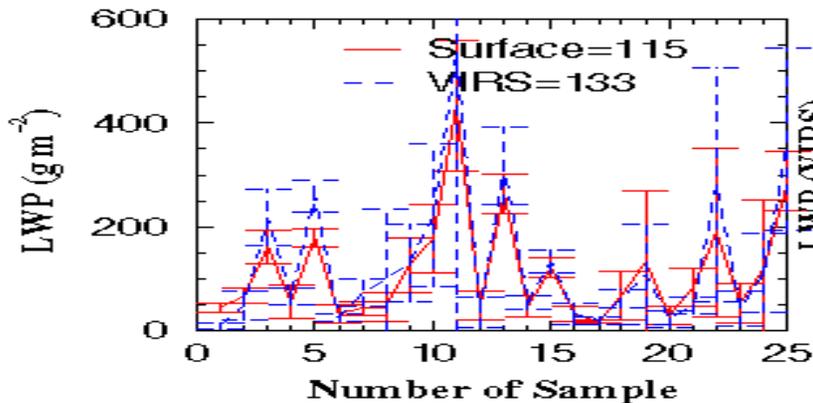
Daytime VIRS and Surface Comparison at ARM SGP Site



$\Delta = 8\%$

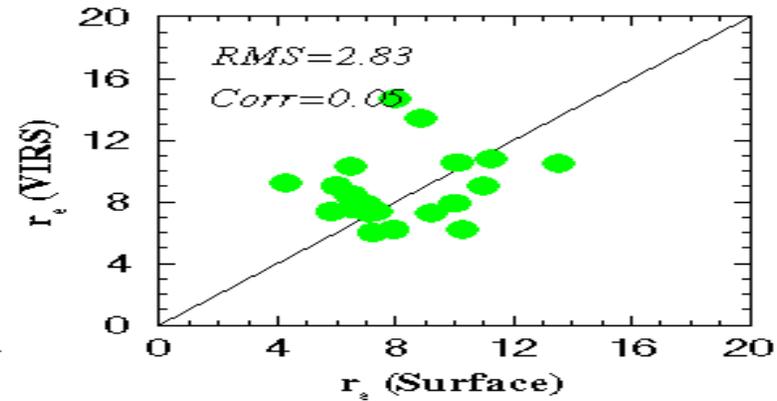
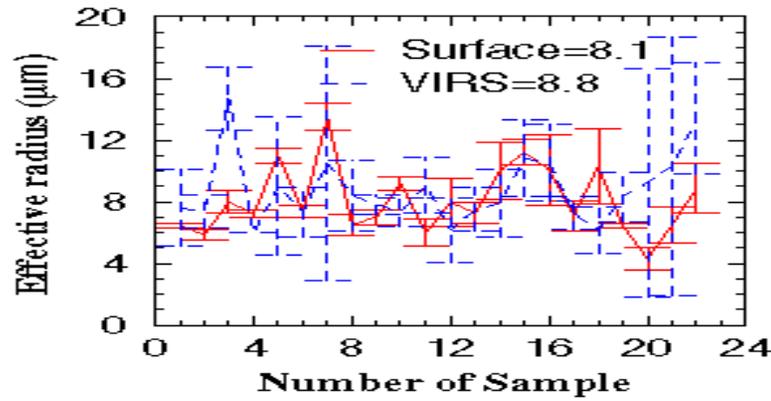


$\Delta = -2\%$

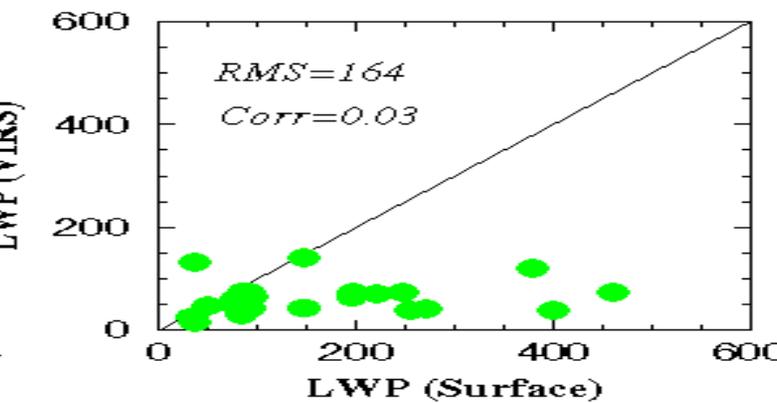
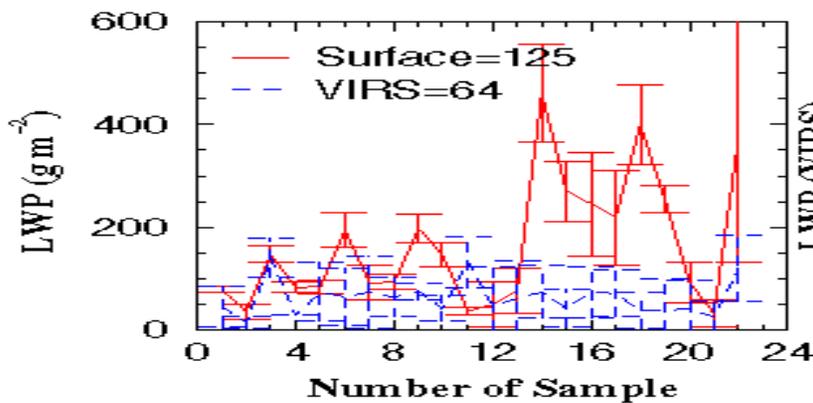
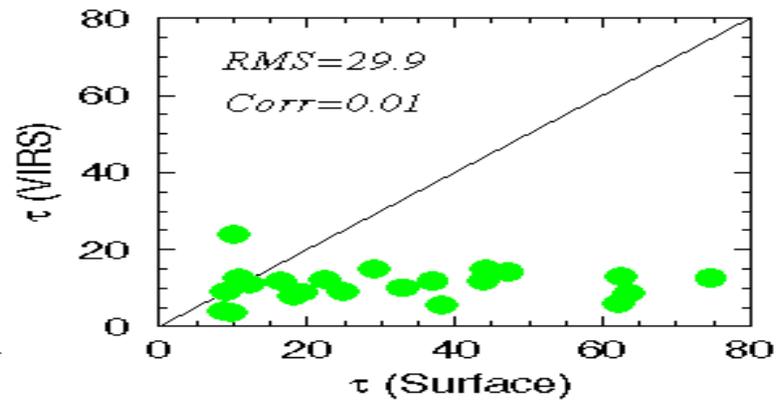
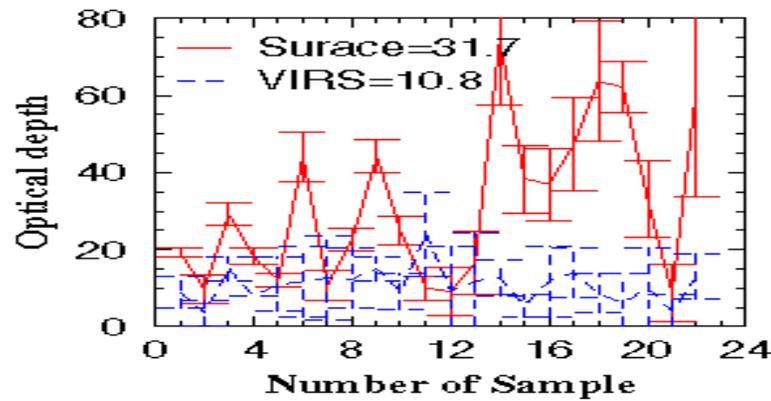


$\Delta = 16\%$

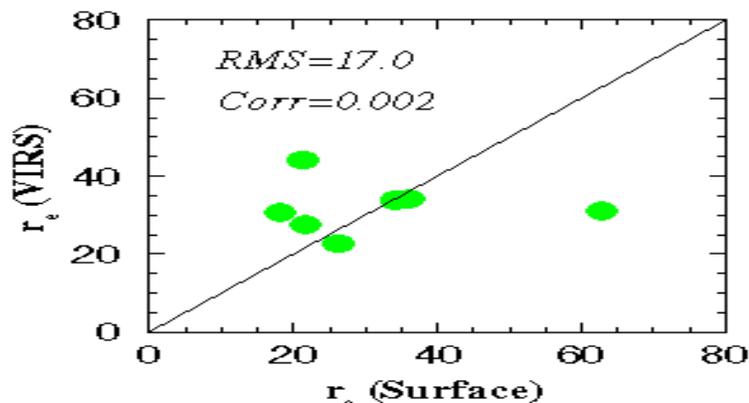
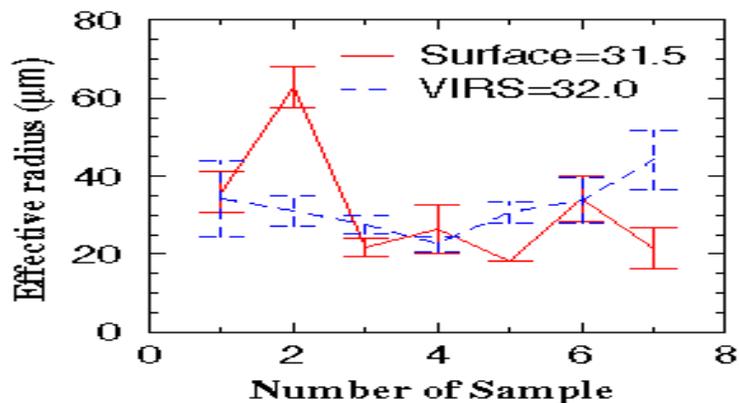
Nighttime VIRS and Surface Comparison at ARM SGP Site



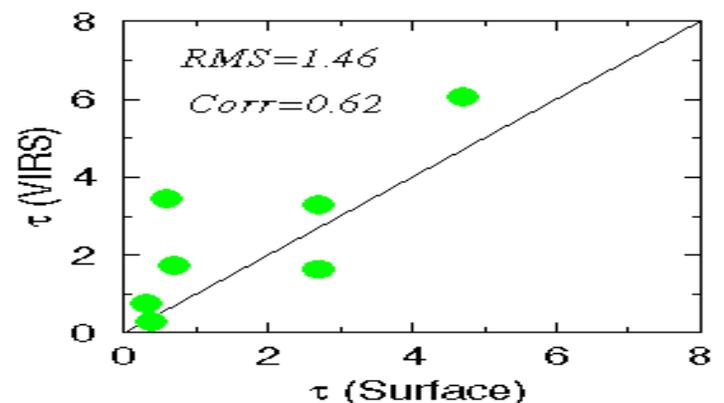
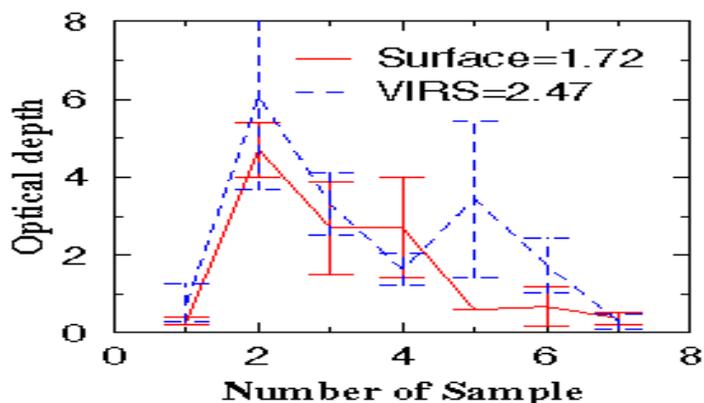
$\Delta = 9\%$



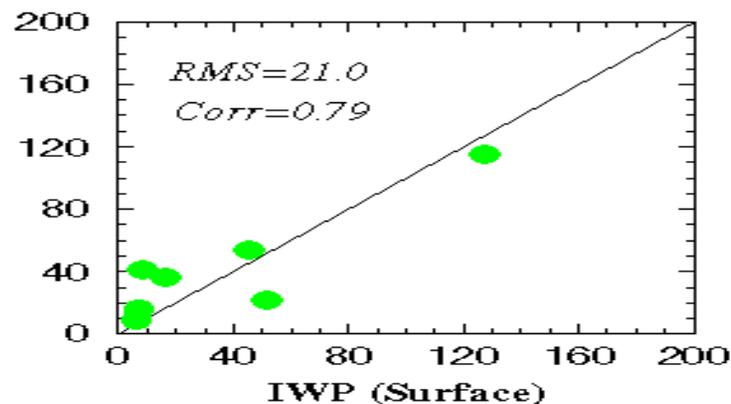
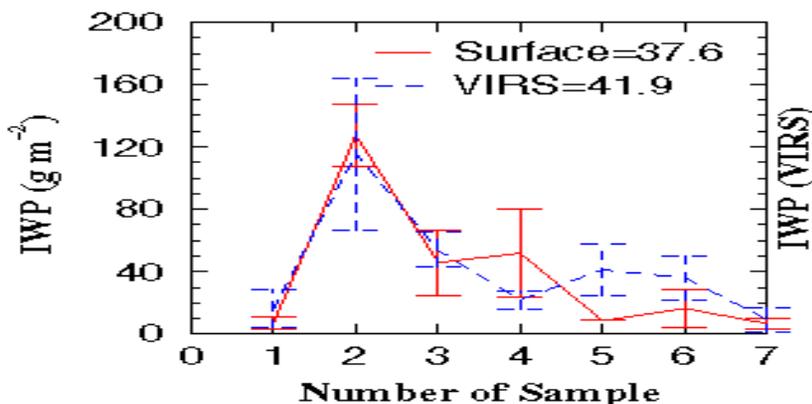
Daytime VIRS and Surface Comparison at ARM SGP Site



$\Delta = 2\%$

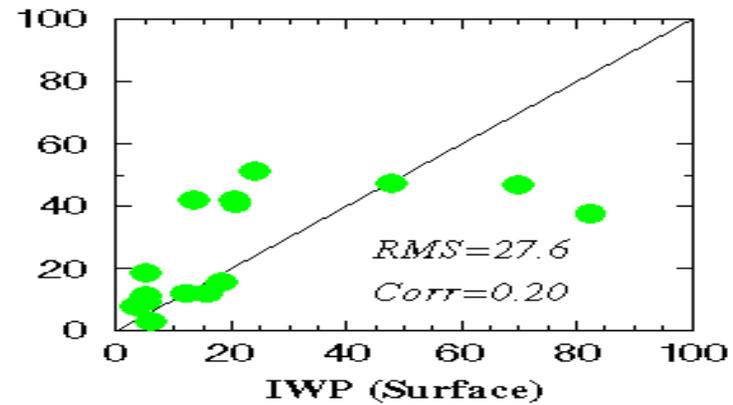
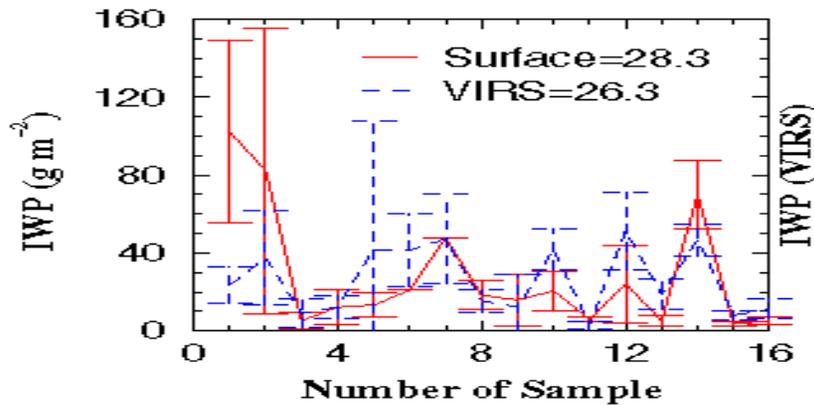
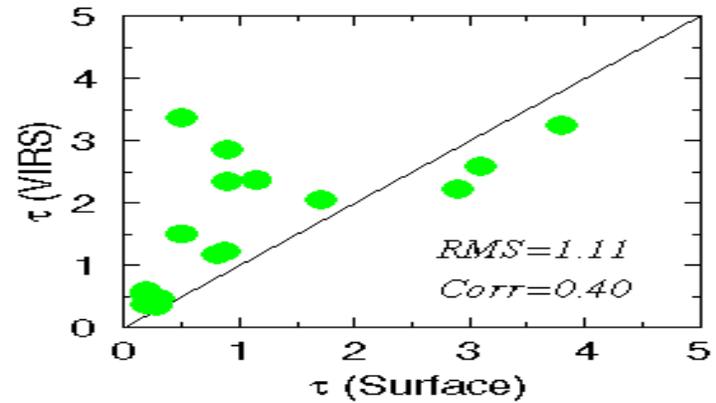
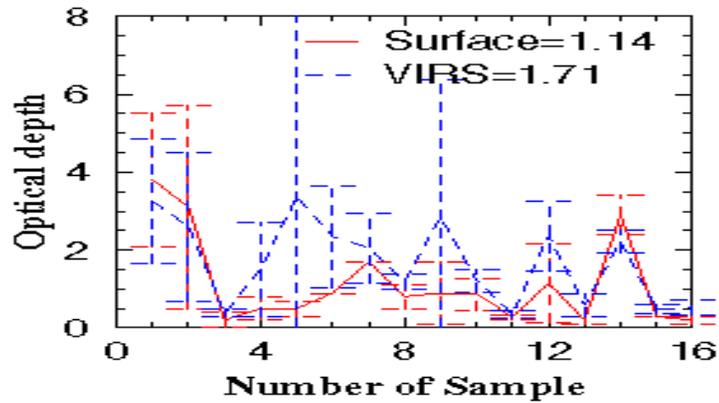
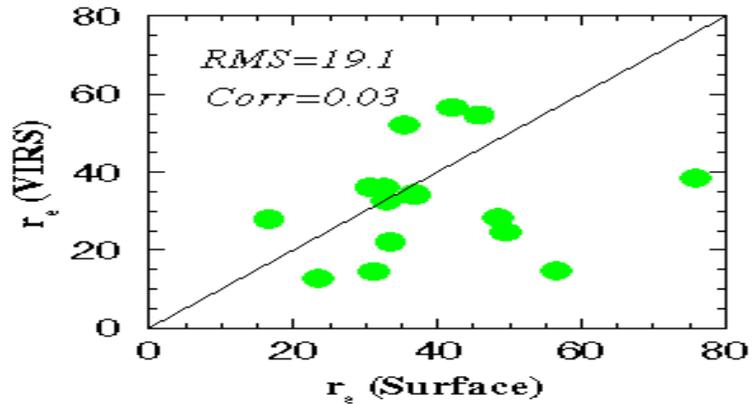
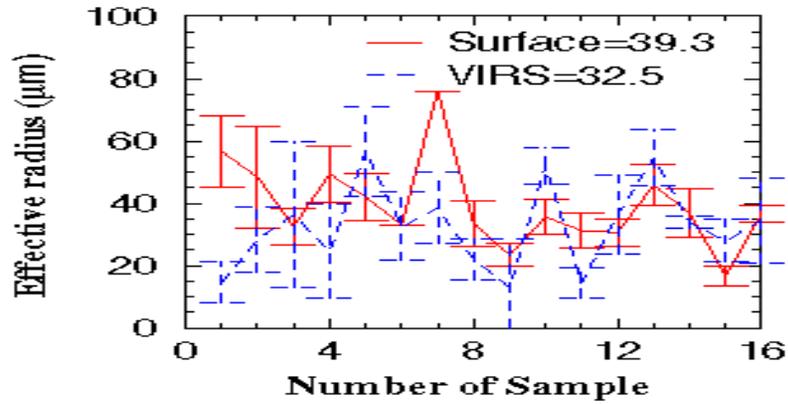


$\Delta = 44\%$



$\Delta = 11\%$

Nighttime VIRS and Surface Comparison at ARM SGP Site



Conclusions

1. VIRS cloud effective height

Daytime

For $\tau > 5$, $Z_{\text{mean}} < Z_{\text{eff}} < Z_{\text{top}}$

For $\tau < 5$, $Z_{\text{base}} < Z_{\text{eff}} < Z_{\text{mean}}$

Night-time

$Z_{\text{eff}} = \text{top} - 0.5 \text{ km}$

$Z_{\text{eff}} = \text{top} + 0.5 \text{ km}$

2. VIRS microphysical properties:

Daytime

For Stratus: **excellent with high corr**

For cirrus: **overall agree well with a relative high corr. need more samples**

Night-time

r_e is OK with low corr.
 τ and lwp underestimated

overall good with a relative low corr.
need more samples

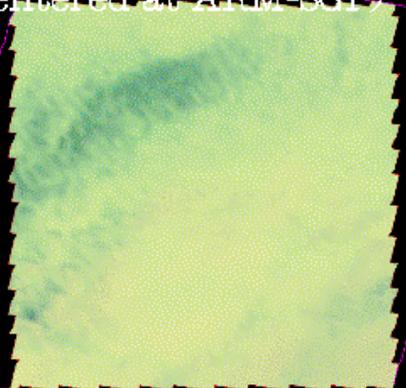
Validation of MODIS results at SGP

- **Sample 1: Daytime stratus on March 29, 2001**
- **Sample 2: Night-time cirrus on March 2, 2001**

2001032917R07 (100km Centered at ARM-SGP)

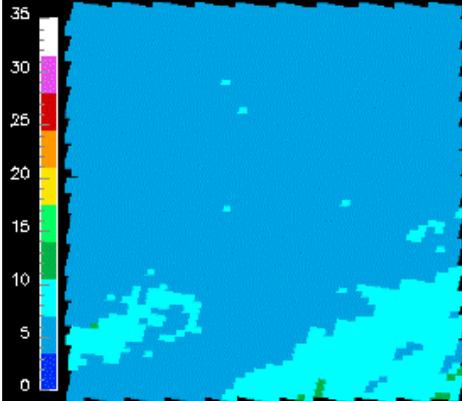


R: 0.6um
G: 1.6um
B: 11um

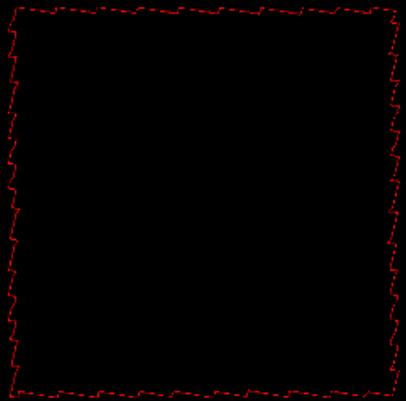
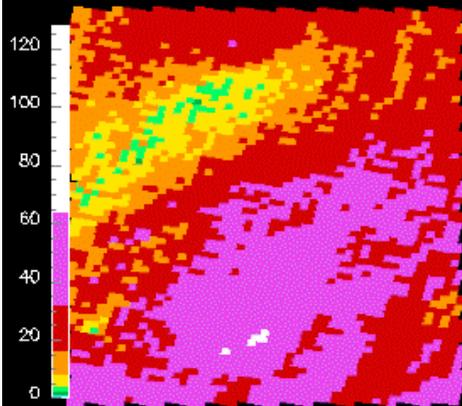


Ice_Gld_Diameter[um]

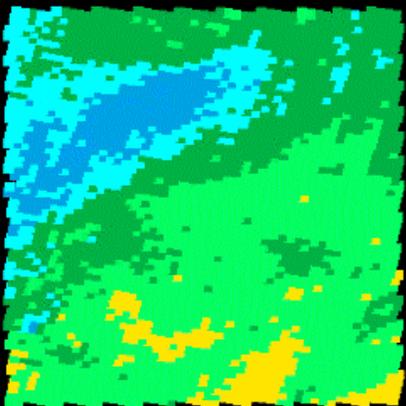
Water_Cld_Radius[um]



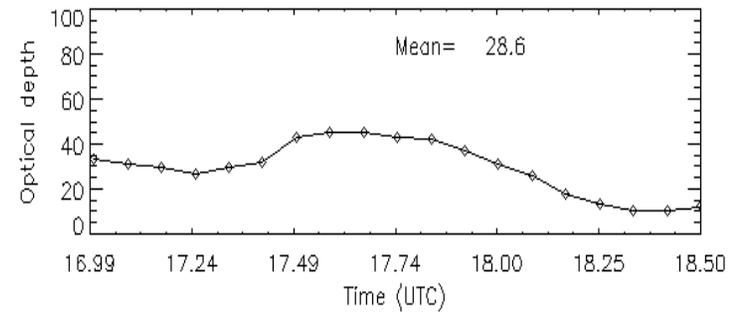
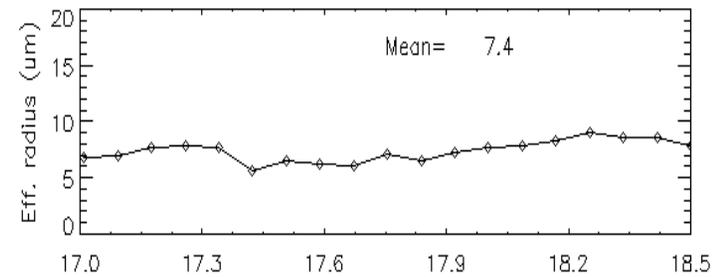
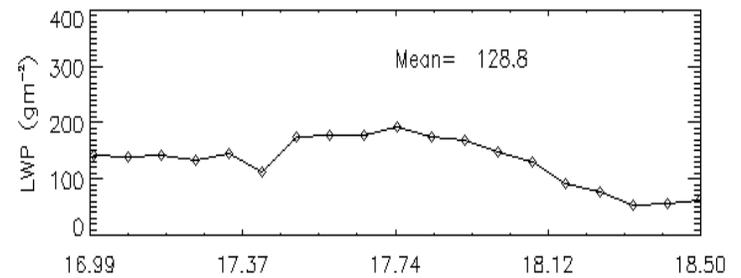
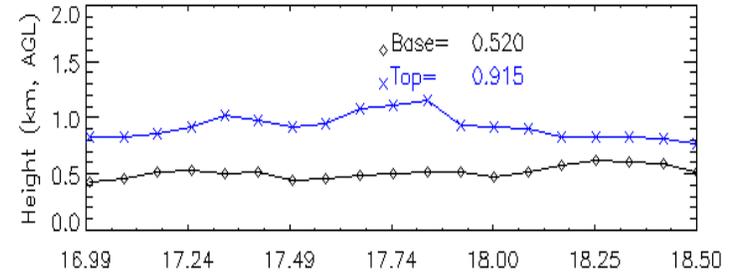
Eff_Cld_Optical_Depth



Cld_Water_Path[g/m^2]



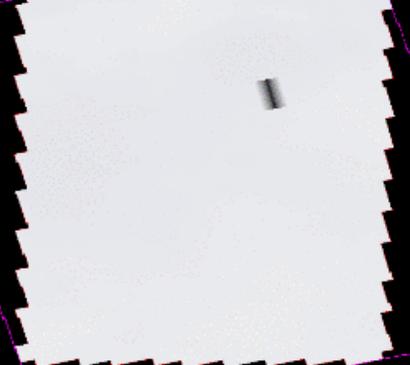
Cloud Properties at the ARM SGP Site (20010329)



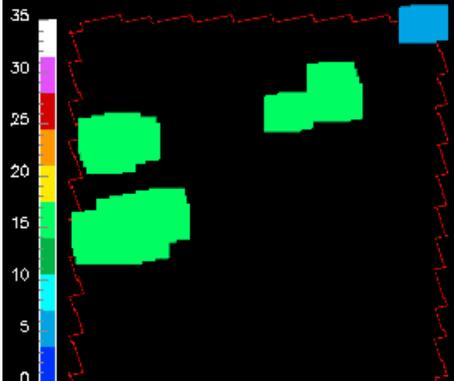
2001030204R07 (100km Centered at ARM-SGP)



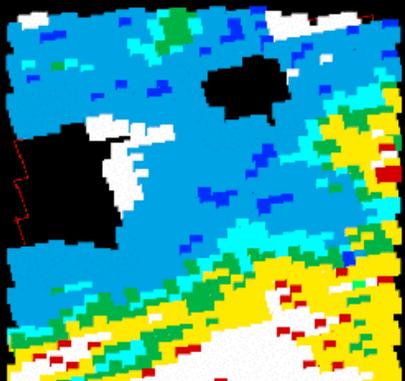
R: 11um
G: 12um
B: 3.7-11um



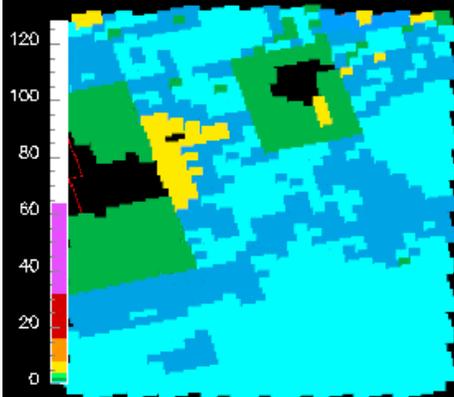
Water_Cld_Radius[um]



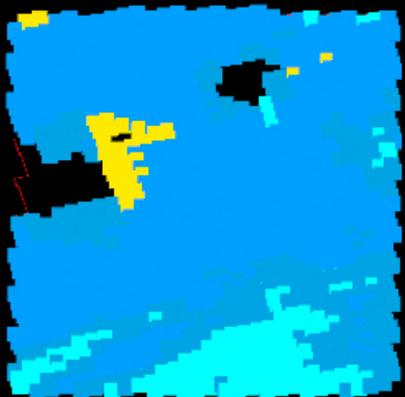
Ice_Cld_Diameter[um]



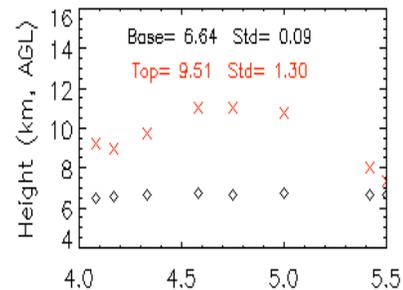
Eff_Cld_Optical_Depth



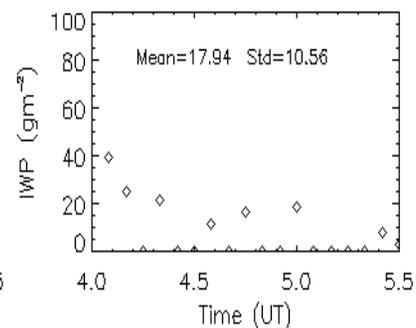
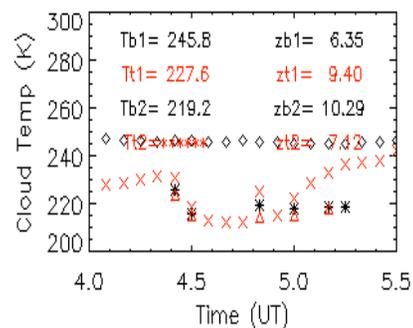
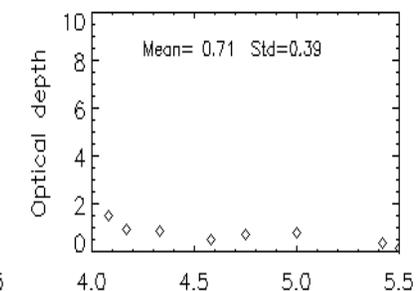
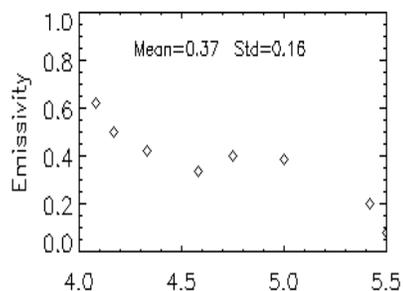
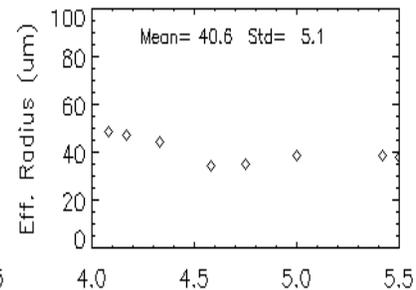
Cld_Water_Path[g/m^2]



Cirrus Cloud Retrievals



at ARM SGP 20010302



Validation of MODIS results at SGP

- **Sample 1: Surface**

VIRS

$Z_b=0.52$ km, $Z_t=0.92$ km, $Z_{\text{eff}}=1.9$ km

$r_e=7.4$ μm ,

$r_e=5.3$ μm

$\tau=28.6$

$\tau=33.2$

$\text{lwp}=128.8$ gm^{-2} ,

$\text{lwp}=107.3$

- **Sample 2: Surface**

VIRS

$Z_b=6.64$, $Z_t=9.51$ km,

$Z_{\text{eff}}=10.38$ km

$r_e=40.6$ μm ,

$r_e=10.5$ μm

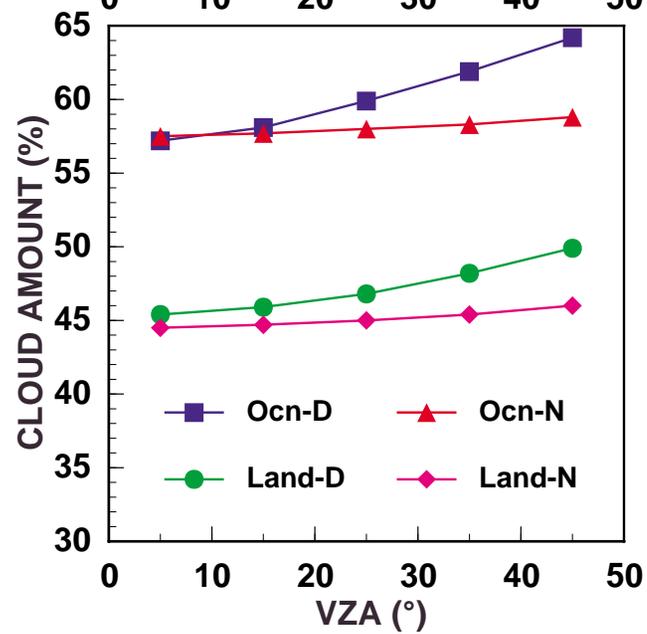
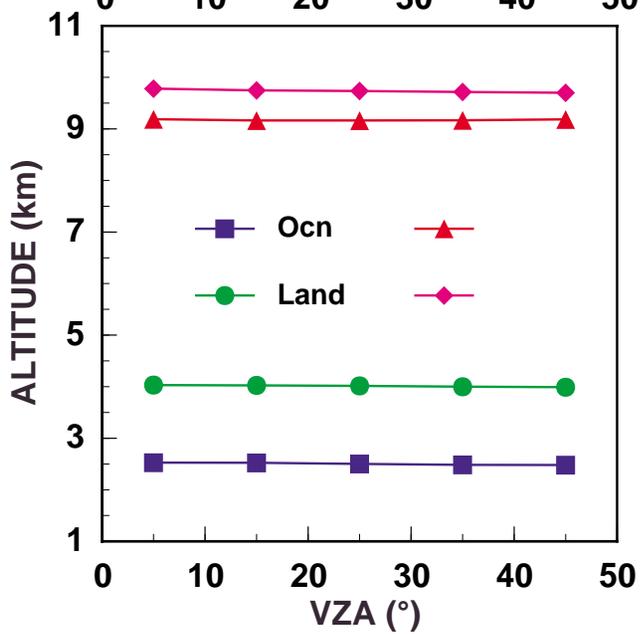
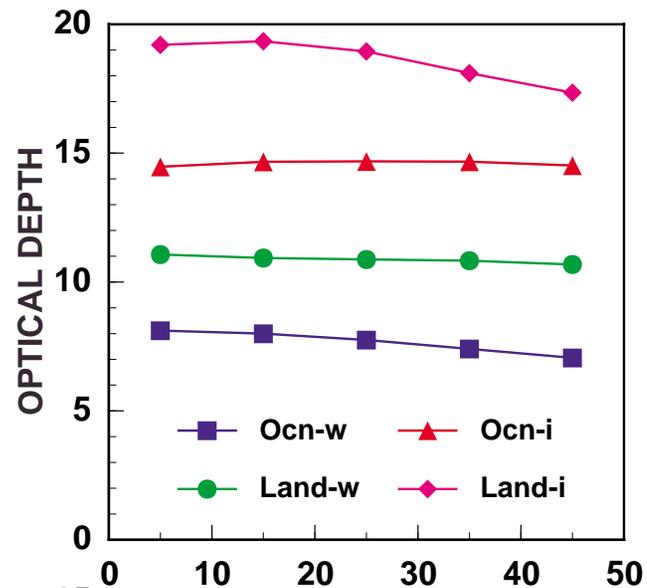
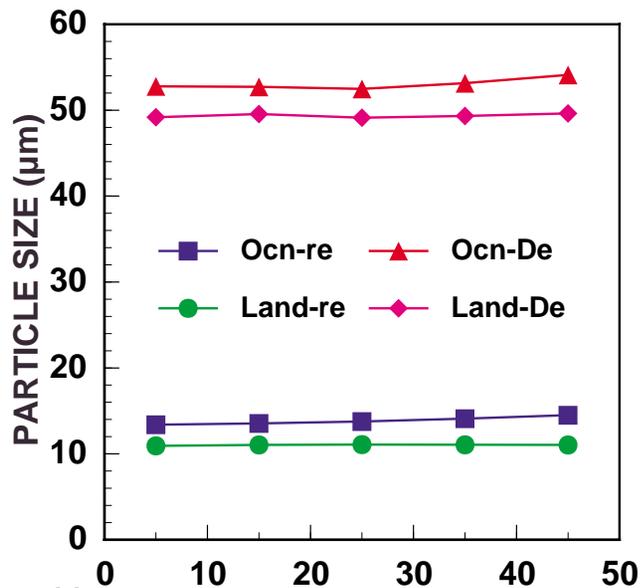
$\tau=0.71$

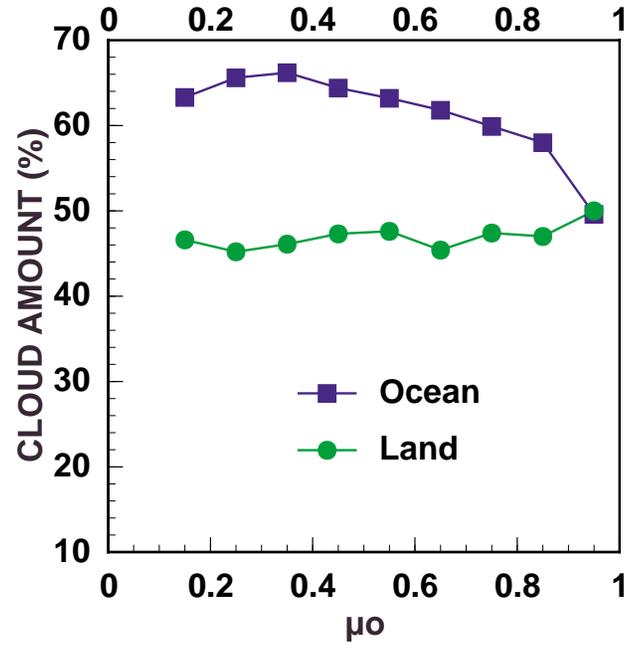
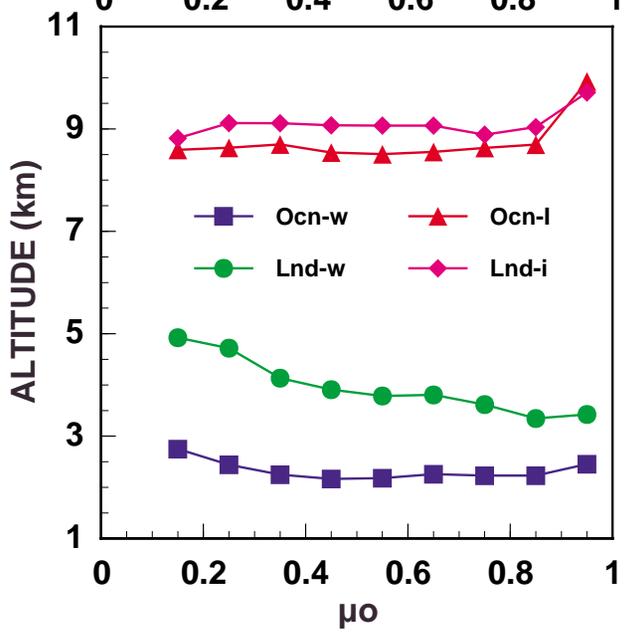
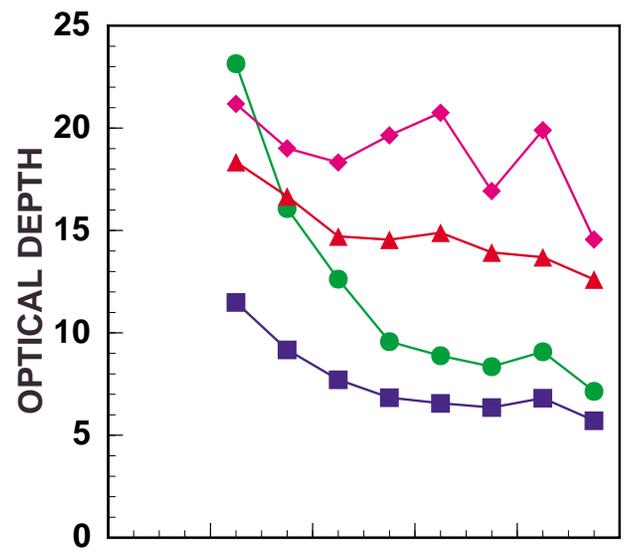
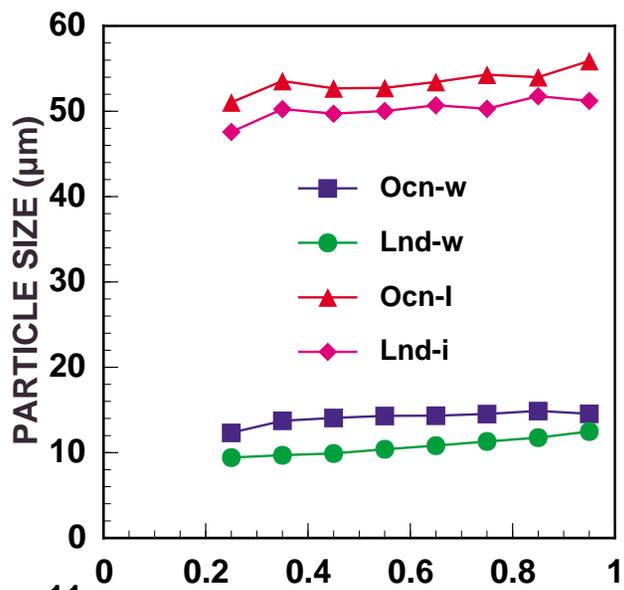
$\tau=0.57$

$\text{IWP}=17.9$ gm^{-2}

$\text{IWP}=3.3$

ANGULAR DEPENDENCE OF CLOUD PROPERTIES





PLANNED IMPROVEMENTS

- **VARIABLE RAYLEIGH SCATTERING DEPENDING ON SENSOR**
- **SENSOR-SPECIFIC CLOUD EMITTANCE MODELS**
- **SENSOR-SPECIFIC SURFACE EMITTANCE MODELS**
- **IMPROVED BLENDING OF POLAR AND REGULAR MASKS**
- **MULTI-LAYER ID**
- **CO2-SLICING**

Diffuse Albedo:
pure Rayleigh atmosphere, non-reflecting surface

